MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXII JANUARY–FEBRUARY, 1940 NO. 1

GEORGIA PYRENOMYCETES I

JULIAN H. MILLER AND G. E. THOMPSON

(WITH 10 FIGURES)

The fungi discussed in this paper were collected in the spring with mature perithecial stages in or on fallen leaves of the previous season. Types are in the University of Georgia Herbarium, and cotypes have been deposited in The New York Botanical Garden, the Farlow Herbarium at Harvard, and in the Mycological Collections of the Bureau of Plant Industry at Washington.

Several of these organisms possess a dothideaceous type of uniloculate stroma with one-celled ascospores. There is a diversity of opinion among mycologists as to the correct genus for such forms, so a brief review of the history of this question is given below.

The authors wish to express their appreciation to Dr. F. J. Seaver, The New York Botanical Garden, and Dr. D. H. Linder, Harvard University, for the loan of specimens.

DISCUSSION OF THE GUIGNARDIA QUESTION

The generic name *Carlia* was proposed by Rabenhorst (**15**) in 1857 with the species *Oxalidis* Rab. as the type. Magnus (**10**) in 1893 thought *Carlia* should include *Laestadia* forms with one-celled ascospores, and so transferred *Sphaerella Bidwellii* Ellis to *Carlia*. Von Höhnel (**6**), on the other hand, says the type *Oxalidis* is known to equal *Mycosphaerella depazeaeformis* (Auersw.), and

[MYCOLOGIA for November-December (**31**: 629–754) was issued December 1, 1939]

as the latter is a typical *Mycosphaerella,* all species should be transferred to *Carlia.*

Sydow (**19**) cites the original description of *Carlia* as follows:

"Sphaeriacearum nov. genus, Hormosporae De. N. affine. Perithecia minuta subglobosa e macula prominula. Sporae sphaericae initio toruloidi —concatenatae, episporio crasso, brunneo. Asci nulli."

From the above the fungus is evidently a conidial stage, and so *Carlia* cannot be used for *Laestadia, Guignardia* or *Mycosphaerella.* Clements and Shear (**4**) recognize this uncertainty and list it among genera dubia.

Laestadia was created by Auerswald (**1**) in 1869, with *Sphaeria alnea* Fries as the type. Von Höhnel (**6**) examines types of the first two species. *Laestadia alnea,* according to him, grows on alder leaves in patches along veins on the underside, with the perithecia under the epidermis, drying disc shaped, with no ostiole, with a diaporthoid nucleus, no paraphyses, very delicate asci at different levels, and spores with four oil drops probably becoming several celled. He says further this is a *Gnomonia* without ostiole and without beak, and places it in a new genus, *Gnomonina* Höhnel. This course is necessary because *Laestadia* Auersw. is preceded by *Laestadia* Kunth. (1832), a Compositae genus. He thinks *Gnomonina alnea* (Fries) Höhnel is related to the Perisporiaceae.

The genus *Guignardia* was erected by Viala and Ravaz (**20**) in 1892 with the single species, *Sphaerella Bidwellii* Ellis, which they named *Guignardia Bidwellii* (Ellis) Viala & Ravaz. According to von Höhnel (**6**) they also intended their new genus to include all species of *Laestadia* Auersw., but they did not realize that *Laestadia* Auersw. is completely different from *Guignardia Bidwellii.* He did not examine material of the latter, but says from illustrations it must be a dothideaceous fungus, and that the conidial stages are homologous to ones of *Carlia* (*Mycosphaerella*), which should be placed in the Phyllachoraceae. Further, this fungus is a *Phyllachora* without paraphyses such as *Phyllachorella. Guignardia* Viala & Ravaz (1892) is hence equal to *Phyllachorella* Sydow (1914), and therefore the name *Laestadia* Auersw. cannot be superseded by *Guignardia,* but must be replaced by *Gnomonina* Höhnel.

Sydow (**19**) says it was not the intention of Viala and Ravaz

to make *Sphaerella Bidwellii* the type of *Guignardia,* but to replace *Laestadia* Auersw. with *Guignardia,* which would make *L. alnea* the type. If this is correct then *Laestadia—Guignardia—Gnomonina* become synonyms, and Clements and Shear (**4**) so arrange them.

Petrak (**11**) thinks it will lead to less confusion to accept *Guignardia* with a concept of characters applicable to *Bidwellii* and then emends the genus. His description includes fruiting body with a stromatic wall, small, perithecium-like, with asci more or less parallel, thick-walled, thickened at the apex, 8-spored, paraphyses lacking, and spores short-clavate, or ellipsoidal, hyaline, one-celled.

Lindau (**9**) describes *Guignardia* with ascospores at maturity with a cross wall near one end, dividing the spore in two very unequal cells. Ellis (**5**) does not mention this end cell. Reddick (**16**), with *G. Bidwellii,* says to all appearances the ascospores are one-celled, but at one end there is a swollen hyaline vesicle, which he formerly regarded as a second cell. Further, he thinks the spore bears at its extremity a little inflated and transparent mucilaginous material which aids in fixing the spore to the leaf. Von Höhnel (**6**) says Schroeter describes an end cell, which is entirely wrong, as the spores at maturity remain one-celled. The writers in examining sections of both *G. Bidwellii* and *G. Aesculi* (Peck) Stew. find the spores to be one-celled.

Clements and Shear (**4**) place fungi with characters of *Guignardia Bidwellii,* that is, according to their key, with innate perithecia, not beaked, neither paraphyses nor paraphysoids, and one-celled ascospores, in the genus *Phomatospora* Sacc. As synonyms under this genus they have *Laestadia* Auersw., *Guignardia* Viala & Ravaz, and *Gnomonina* Höhnel. The type of *Phomatospora* is *P. Berkeleyi* Sacc. (1875).

Saccardo (**7**) describes the species *Berkeleyi* from *Sphaeria phomatospora* Berk. & Br. Von Höhnel (**7**) examines the type and finds delicate paraphyses, uniseriate, one-celled ascospores, wall of perithecium thin, membranous-leathery, beak spherical to almost cylindrical, and no diaporthoid nucleus. He says it is a *Ceratostomella* with or without a short beak.

Petrak (**12**) in describing *Phomatospora Filarszkyi,* says the

genus has no genuine paraphyses, but delicate pseudoparaphyses and it stands near the Diaporthaceae. Then later (**13**) under *Phomatospora moravica,* he says pseudoparaphyses sparse, thread-like, branched, later dissolving, and that the genus is near *Ceratostomella.* According to Petrak then the *Phomatospora* concept is entirely different from that of *Guignardia* with its stromatic fruiting body and no threads in the centrum.

The writers in this paper will follow Petrak in considering *Sphaerella Bidwellii* the type of *Guignardia,* and so restrict the genus to forms with uniloculate stromata, with no beak, fasciculate asci, no paraphyses, and one-celled ascospores.

1. **Guignardia Bumeliae** sp. nov.

Perithecia hypophylla, sparsa, semiimmersa, depresso-globosa, nigra, 92–100 × 104–120 μ, ostiolo plano, pariete pseudoparenchymate; asci fasciculati, clavati, breviter stipitati, 60–65 × 14–16 μ, 8-spori; sporae distichae vel inordinatae, ellipticae, utrinque obtusae, continuae, hyalinae, 14–18 × 7.5–9 μ; aparaphysata.

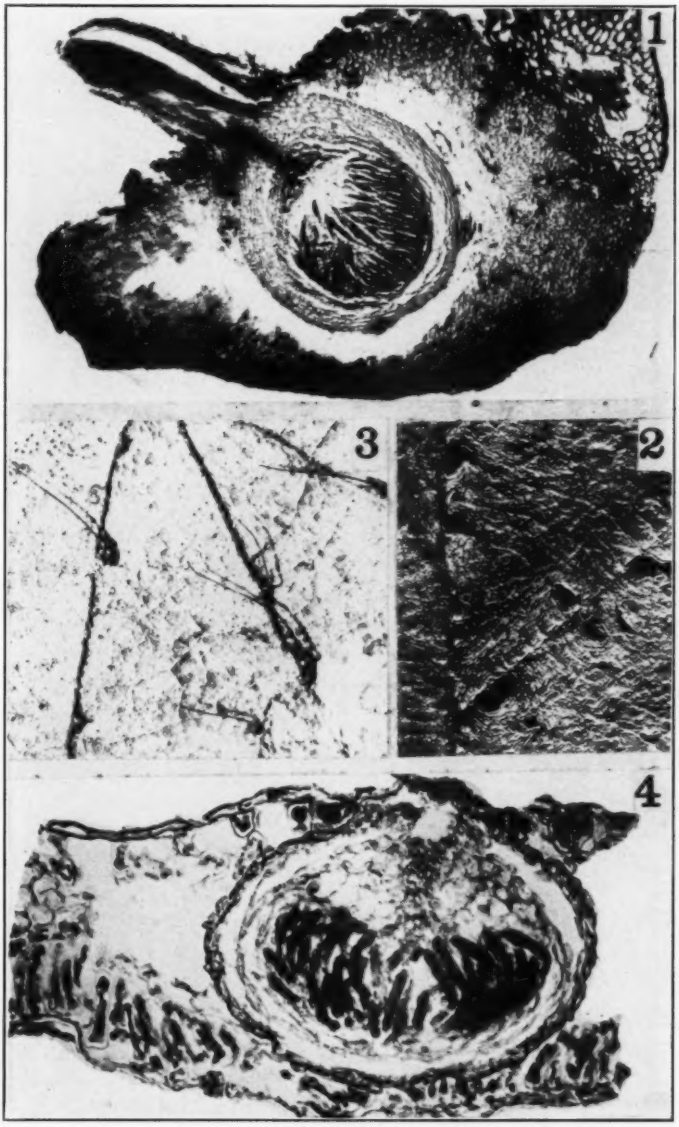
Perithecia chiefly hypophyllous, not in spots, evenly distributed over entire leaf surface, immersed, later partially erumpent, depressed-globose with flat to rounded apices with widely punctiform ostiole, and walls composed of brown pseudoparenchymatous cells, 10–23 μ thick, 92–100 × 104–120 μ; asci few, fasciculate, arising from a conical basal plectenchyma, clavate, with rounded apices and short stalks, 8-spored, 60–65 × 14–16 μ; spores biseriate to inordinate, broadly ellipsoid with obtuse ends, continuous, hyaline, 14–18 × 7.5–9 μ; no paraphyses. Fig. 10.

On *Bumelia lycioides* Gaertn., in fallen leaves. Little River, 10 mi. n.w. Milledgeville, Ga. Mar. 20, 1939.

2. SPHAEROGNOMONIA CARPINEA (Fries) Poteb. Ann. Myc. **8**: 53. *fig. 6–7.* 1910.

Sphaeria carpinea Fries, Syst. Myc. **2**: 523. 1823.
Laestadia carpinea Sacc. Syll. Fung. **1**: 426. 1882.

This fungus is interesting in that while it has certain characters closely approaching *G. Bidwellii,* there are other more fundamental ones, especially those of the perithecial centrum, which justify separate genera. It is quite common in Georgia, but it apparently has not found its way into American literature under the above name.



FIGS. 1–3. *Mamiania Alni;* 4, *Sphaerognomonia carpinea.*

The genus *Sphaerognomonia* was erected by Potebnia (**14**) in 1910, with *Sphaeria carpinea* Fries as the type. In his figure 6 he shows an uniloculate stroma, with no beak, opening by a break in the tissue over the asci, with more or less parallel-fasciculate asci, each with a ring pore in the apex, and one-celled hyaline ascospores. He says this shows an affinity to *Gnomonia*. The difference is in the lack of a beak.

Von Höhnel (**6**) says this is *Sphaeria carpinea* Fries and that Potebnia in his figure 6 has shown the asci falsely by having them parallel, and they should have been diaporthoid. Also, this is a *Gnomoniella* with a clypeus and without a beak, and he recognizes the genus *Sphaerognomonia*.

The writers have sectioned material of this species collected on *Carpinus* at Athens, and figure 4 shows a median section. The essential characters are the same as those portrayed by Potebnia's figure. It is an uniloculate stroma and not a true perithecium, the outer wall cells are large with thick, dark-brown walls, while the inner ones are thin-walled and pseudoparenchymatous, and above the stroma is a well marked clypeus in the epidermis. The apex is flat with no beak. The asci arise from the bottom and are more or less fasciculate, and are not diaporthoid in different levels as is true of species of *Diaporthe, Valsa,* or *Gnomonia*. They do not fill up the centrum as do those in the perithecium in figure 5. There is definite stromatic tissue above the asci, occupying about one-third of the stroma.

The ostiole is formed in a peculiar manner. When the asci are very young a vertical line of very small meristematic cells, deeply staining, forms in the stroma from a position directly over the center of the asci and continuing through to the surface of the apex. This can be seen in figure 4. The central elements in this line dissolve in the mature perithecium leaving a pore for the discharge of the ascospores. No periphyses were seen in the ostiole, nor were there any paraphyses among the asci even at a very young stage.

There is a very definite ring pore in the apex of the asci as illustrated by Potebnia's figure 7. Also, the asci are short-stalked, easily floating out in water. This fungus then has these diaporthoid characters, but the organization of the wall and the stroma

above the asci are indicative of the Dothideales. The writers consider *Sphaerognomonia* as showing more close relationship to *Mycosphaerella* and *Guignardia* than to *Gnomonia,* and it should be so grouped in a natural system. On the other hand it is probable that perithecial forms with the diaporthoid centrum and a well organized wall as *Gnomonia* may have arisen from such a fungus as *Sphaerognomonia carpinea* by the development of an inner organized wall.

The chief separations now between *Guignardia* and *Sphaerognomonia* lie in the ascus pore and the floating out of the asci in the latter, and no pore and more or less tightly held asci in the former. Both have one-celled hyaline ascospores, and the asci lie in a stromal cavity.

Sphaerognomonia carpinea has been found in Georgia on the following apparently new hosts: *Acer rubrum* L., *Alnus rugosa* (DuRoi) Spreng., *Betula nigra* L., *Castanea dentata* (Marsh.) Borkh., and *Ostrya virginiana* K. Koch., as well as on *Carpinus caroliniana* Walt. Perithecia are found on overwintered leaves in the spring, and are morphologically indistinguishable on the different hosts, but may differ in parasitism as no cross inoculations studies were made.

3. **Sphaerognomonia polystigma** (Ellis & Ev.) comb. nov.

Sphaerella polystigma Ellis & Ev. Bull. Torrey Club **10**: 117. 1883.

Anisostomula polystigma Höhnel, Ann. Myc. **16**: 49. 1918.

This species has very much the same characters as found in *Sphaerognomonia carpinea.* The type specimen, N.A.F. *1353,* was examined and the stroma opens by the dissolution of a meristematic line above the asci as in the former, and the ascospores have the same measurements, 10–12 × 4–6 μ. No morphological characters could be found that warranted its retention as a separate species. However, as conidial stages were not studied nor inoculations made, the writers will temporarily consider it distinct.

Von Höhnel (**6**) created the genus *Anisostomula* with *Laestadia Cookeana* Auersw. as the type, and describes the following distinctive characters: paraphyses numerous at an early stage, later dissolving, asci in one layer, not diaporthoid, no ostiole nor beak,

cross plate in apex of ascus. He follows with a description of *Laestadia polystigma* which he places in *Anisostomula*. The writers, on the other hand, found no paraphyses in the type and none in fresh material even at a very early stage, and do find a diaporthoid centrum in that the asci float out in exactly the same manner as in *Sphaerognomonia carpinea*. Therefore, the fungus on *Quercus* should be placed in the same genus with the one on *Carpinus*.

The type of *Sphaerognomonia polystigma* is on *Quercus coccinea* Muench. In addition to this oak, it has also been collected in Georgia on the following species which apparently represent new hosts: *Quercus alba* L., *Q. borealis* Michx. var. *maxima* Sarg., *Q. cinerea* Michx., *Q. marilandica* Muench., *Q. nigra* L., *Q. palustris* Muench., *Q. Prinus* L., *Q. stellata* Wang., and *Q. velutina* Lam.

4. **Gnomoniella georgiana** sp. nov.

Perithecia epiphylla, dispersa, semiglobosa, 350–450 × 220–275 μ, rostris breviter papillatis, erumpentibus, immersa, pariete coriaceo-membranaceo, brunneo, 12–20 μ crasso; asci numerosi, clavati, breviter stipitati, 69–80 × 12–16 μ, 8-spori; sporae distichae vel inordinatae, oblongo-ellipsoideae, obtusae, hyalinae, continuae, 15–23 × 6–10 μ; paraphyses initio evolutae, aetate, omnino mucosae.

Perithecia epiphyllous, irregularly dispersed, slightly depressed-globose, large, 350–450 × 220–275 μ, entirely immersed in the mesophyll, with short papillate, erumpent ostiola, about 90–100 μ high; perithecial walls coriaceous-membranaceous, composed of concentrically arranged very small cells, 12–20 μ thick; asci numerous, clavate, with rounded apices, and lower ends attenuated, short stipitate, becoming free in water, 69–80 × 12–16 μ, 8-spored; spores biseriate to inordinate, oblong-ellipsoid, obtuse, continuous, hyaline, thin-walled, straight or slightly curved, 15–23 × 6–10 μ; paraphyses present at an early stage, but gelatinizing at maturity (FIG. 5).

This fungus has a definitely organized wall and a centrum filled with asci that float out in water, which places it in the family Diaporthaceae. The length of the beak is not as long or as filiform as is found in many *Gnomoniella* or *Gnomonia* species, but is about equal to that of *Gnomonia ulmea* (Schw.) Thüm.

On dead leaves both on the ground and on the tree. Type on *Nyssa biflora* Walt., swamp 7 mi. west Harlem, Ga., Mar. 16,

1939, also on that species at Towns Creek, Washington Co., Ga., Mar. 20, 1939; on *Nyssa sylvatica* Marsh. Agri. Campus, Athens, Ga., Mar. 21, 1939; on *Liquidambar Styraciflua* L. Agri. Campus, Athens, Ga., Mar. 11, 1939; and 4 mi. southeast of Thomson, Ga., Mar. 16, 1939.

5. **Mamiania Alni** sp. nov.

Stromata amphigena, sparsa, orbicula vel irregulariter, levia, immersa, superficie atria, intus hyalina, .5–1 mm. in diam.; perithecia solitaria, in centro stromatis, semiglobosa, 250–276 × 295–300 μ, rostris filiformibus, hypophyllis, 2–7 mm. longis, pariete brunneo, coriaceo-membranaceo, 35–46 μ crasso; asci lati, clavato-fusoidei, breviter stipitati, 57–64 × 6.9–13.8 μ, 8-spori; sporae inordinatae, fusoideo-ellipsoideae, rectae, 1-septatae, leniter constrictae, hyalinae, 16–23 × 4 μ; paraphyses paucae, mox mucosae.

Stromata smooth, orbicular to irregular, sparsely dispersed over leaf surface, immersed in the mesophyll, equally visible from both sides, externally black with hyaline interior, .5–1 mm. in diam.; perithecia single in stroma, semiglobose, 250–276 × 285–300 μ, with brown coriaceous-membranaceous walls, 35–46 μ thick, with a filiform beak on lower side of leaf, 2–7 mm. long; asci in wall layer, becoming loose in cavity, 8-spored, broadly fusoid-clavate, with short attenuate filiform stalks, 57–64 × 6.9–13.8 μ; spores crowded, hyaline, 2-celled but with four oil drops, fusoid-ellipsoid, straight, slightly constricted at septum, 16–23 × 4 μ; paraphyses sparse, dissolving into a slimy mass at maturity (FIGS. 1, 2, 3).

The stromata were first seen in dead alder leaves in September, but the perithecia were not mature until the following summer.

On *Alnus rugosa* (DuRoi) Spreng., Agri. Campus, Athens, Ga., July 5, 1939.

The genus *Mamiania* Cesati & DeNotaris (1863) is based on *Sphaeria fimbriata* Pers. ex Fries. Von Höhnel (**8**) in a note on *Mamiania,* says the perithecial centrum is typically diaporthoid, and the perithecia are sunken in a white stroma with a black border. These characters fit the above species. Then he further says the spores are very unequally two-celled. The writers do not consider this difference sufficient in this case to provide grounds for a new genus.

The second species described by Cesati and DeNotaris (**3**) is *M. Coryli* (Batsch ex Fries) Cesati & DeNotaris, and it has continuous spores, and is the type of von Höhnel's (l.c.) genus, *Mamianiella.*

This fungus has all of the characters of a *Gnomonia* with the additional one of the stroma. It differs from *Diaporthe* only in that it occurs on leaves and not on wood or bark.

6. **Ophiodothella leucospila** (Berk. & Curt.) comb. nov.

Sphaeria leucospila Berk. & Curt. Grevillea **4**: 153. 1876.
Linospora leucospila Sacc. Syll. Fung. **2**: 357. 1883.

This species was very briefly and inadequately described by Berkeley, and Ellis (**5**) saw no actual material, but copied the former's description. Since it occurs quite commonly in north Georgia the writers will add the following characterization.

Perithecia hypophyllous in light colored areas along sides of the midrib and chief lateral veins, sunken in mesophyll, under a black epidermal clypeus, with a well organized wall of concentrically arranged cells, which penetrates the clypeus forming a short papilla, with a narrow ostiole; asci cylindric, 8-spored, 80–100 × 4.6 μ; spores filiform, about as long as the ascus and 1 μ thick; paraphyses present, tending to disappear with maturity.

This species is placed in *Ophiodothella* because of the lack of an ostiolar beak. The type of *Linospora* is *L. Capreae* (DC.) Fuckel, on *Salix*, and of *Ophiodothella* is *O. atromaculans* P. Henn. Both have perithecia in a pseudostroma and under a distinct clypeus and the beak is the only distinguishing character.

According to Clements and Shear (**4**) the above species would fall in *Ceuthocarpon* Karst. with no beak. The type is *Linospora populina* (Pers. ex Fries) Schr. on *Populus tremula*, and the specimen on poplar leaves (Sydow, Myc. Germ. *249*) has distinct beaks on most of the perithecia 250–500 μ high, and broken ones on the rest, and so *Ceuthocarpon* should be a synonym of *Linospora*.

On overwintered leaves of *Platanus occidentalis* L., Princeton, Ga., Mar. 31, 1939; Tallassee Shoals, Ga., May 1, 1939; and near Sandersville, Ga., Mar. 20, 1939.

7. **Didymosphaeria Chionanthi** sp. nov.

Perithecia hypophylla, dispersa vel aggregata nervisequa, immersa, semiglobosa, rostris breviter papillatis, 200–250 × 170–200 μ, pariete coriaceo-membranaceo brunneo, ca. 7–12 μ crasso; asci clavati, breviter stipitati, 69–75 × 10–15 μ, 8-spori; sporae distichae, oblongo-fusoideae, utrinque obtusae, leniter arctuatae, 1-septatae, plus minus constrictae, dilute brunneae, 18–22 × 4–5 μ; paraphysoides fibrosae.

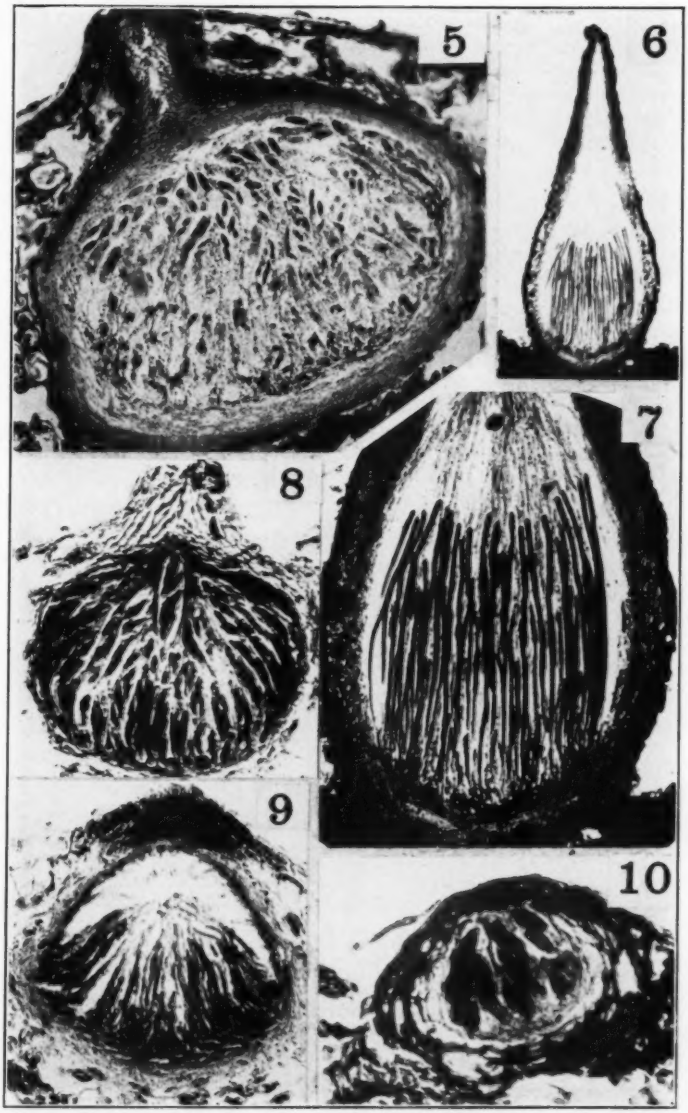


FIG. 5. *Gnomoniella georgiana;* 6, 7, *Acrospermoides subulata;* 8, *Didymosphaeria Magnoliae;* 9, *Ophiodothella leucospila;* 10, *Guignardia Bumeliae.*

Perithecia hypophyllous, irregularly scattered, chiefly along the veins, semiglobose, 200–250 × 170–200 μ, with short papillate beaks, immersed in the mesophyll, walls thin and membranaceous, 7–12 μ thick; asci embedded in thread-like paraphysoids, clavate with attenuate, short stalks, 60–75 × 10–15 μ; spores biseriate, oblong-fusoid, with obtuse ends, slightly curved, 1-septate, slightly constricted, lower cell somewhat larger than the upper, dilute brown, 18–22 × 4–5 μ.

On dead leaves of *Chionanthus virginicus* L., Little River, 10 mi. northwest of Milledgeville, Ga., May 6, 1939.

8. **Didymosphaeria Magnoliae** sp. nov.

Perithecia epiphylla, dispersa, immersa vel leniter erumpentia, semiglobosa, apicis papillatis, 138–160 × 115–140 μ, pariete brunneo pseudoparenchymate, 10–15 μ crasso; asci lato-clavati, breviter stipitati, 62–74 × 11–14 μ, 8-spori; sporae distichae, oblongo-fusoideae, rectae vel curvatae, utrinque leniter acutae, 1-septatae, leniter constrictae, dilute olivaceo-brunneae, 18–23 × 4.6–6.9 μ; paraphysoides filiformae, ramosae.

Perithecia epiphyllous, sparsely aggregated, immersed, later partially erumpent, semiglobose, 138–160 × 115–140 μ, with conical papilla, 40–50 μ high, composed of vertical, elongate cells, walls of perithecium brown pseudoparenchymatous, 10–15 μ thick; asci arising from base, embedded in thread-like paraphysoids, broadly clavate, short stipitate, 62–74 × 11–14 μ, 8-spored; spores biseriate, oblong-fusoid, straight to curved, 1-septate, slightly constricted at the septum, dilute olivaceous-brown, 18–23 × 4.6–6.9 μ (FIG. 8).

In dead leaves on ground, *Magnolia virginiana* L., swamp 8 mi. west of Sandersville, Ga., Mar. 20, 1939.

The above two species of *Didymosphaeria* with a stromatic type of wall and paraphysoides attached at the top as well as the bottom of the centrum should be grouped in the Pseudosphaeriales connection.

Acrospermoides gen. nov.

Perithecia superficialia, globosa-conica, rostris subulatis, atra, pariete membranaceo-coriaceo, levia; asci cylindracei, in paraphysoidibus, 8-spori; ascosporae hyalinae, filiformae.

Perithecia free on substratum, flask-shaped with subulate beak, black, wall membranaceous-coriaceous, smooth; asci cylindric, in paraphysoids, 8-spored; ascospores hyaline, filiform.

9. **Acrospermoides subulata** sp. nov.

Perithecia hypophylla, superficialia, aequaliter dispersa, atra, globosa-conica, rostris, elongato-subulatis, 380–495 × 150–185 μ, pariete coriaceo-membranaceo, 30–35 μ, crasso, exteriore e stratis cellularum atro-brunnearum composito, intus e stratis hyalinis, paraphysoidibus in centro perithecei et in ostiolo; asci cylindracei, basibus attenuatis, 150–160 × 4.6 μ, 8-spori; sporae filiformae, 145–163 × 1 μ, hyalinae, continuae.

Perithecia hypophyllous, superficial, uniformly distributed over the leaf surface, black, flask-shaped with elongate beaks, 380–495 × 150–185 μ, with walls coriaceous-membranaceous, brittle when dry, 30–35 μ thick, outer cells dark and inner ones hyaline; paraphysoids in perithecial centrum and in ostiole; asci cylindric tapering to stipe-like base, 150–168 × 4.6 μ, 8-spored; spores filiform, nearly as long as the ascus, 145–163 × 1 μ, hyaline, continuous (FIG. 6, 7).

On dead leaves, *Morus rubra* L., Agri. Campus, Athens, Ga., Feb. 1, 1939; Princeton, Ga., Mar. 31, 1939; Tallassee Shoals, Ga., Mar. 18, 1939; and Watson Springs, Ga., Mar. 22, 1939.

This species closely approaches *Acrospermum* in perithecial centrum characters, but differs in the shape of the fruiting body. In the latter it is cylindric to cuneate and terete to compressed, expanding upward, while in *Acrospermoides* the basal portion is enlarged, tapering to an acuminate apex. Also in *Acrospermum* the asci extend entirely to the tip, while in this species they attain only about one-third of the perithecial height. In both there are paraphysoids, which would indicate a Pseudosphaeriales connection as pointed out by Brandriff (**2**) for *Acrospermum*.

Clements and Shear (**4**) in the Sphaeriaceae—hyaloscoleciae—have only the genus *Leptosporella* Sacc. as a possibility for perithecia of this type. The type is *L. gregaria* Penz. & Sacc. with spores cylindric-vermiform as illustrated by Saccardo and Penzig (**18**), *pl. 16, fig. 1*). This kind of spore is typical of *Lasiosphaeria* Cesati & DeNotaris, and von Höhnel (**6**) places *Leptosporella* as a synonym under *Thaxteria* Sacc., which he makes a segregate of the older concept of *Lasiosphaeria*.

DEPARTMENT OF PLANT PATHOLOGY
UNIVERSITY OF GEORGIA
ATHENS, GEORGIA

LITERATURE CITED

1. **Auerswald, B.** *Laestadia,* nov. Perisporiacearum genus. Hedwigia **8:** 177. 1869.
2. **Brandriff, Helen.** The development of the ascocarp of *Acrospermum compressum.* Mycologia **28:** 228–235. 1936.
3. **Cesati, V. de & DeNotaris, G.** Comm. Soc. Critt. Ital. **1:** 210. 1863.
4. **Clements, F. E. & Shear, C. L.** The genera of fungi. 496 pp. H. W. Wilson Co. 1931.
5. **Ellis, J. B. & Everhart, B. M.** The North American Pyrenomycetes. 793 pp. Newfield, N. J. 1892.
6. **Höhnel, F. von.** [Mycologische Fragmente.] CCI. Über *Laestadia, Carlia* und *Guignardia.* Ann. Myc. **16:** 46–60; CCXV. Über die Gattung *Lasiosphaeria.* Ann. Myc. **16:** 73–75. 1918.
7. ——. [Mycologische Fragmente.] CCXXVIII. Über die Gattung *Phomatospora.* Ann. Myc. **16:** 90, 91. 1918.
8. ——. [Mycologische Fragmente.] CCXXXVI. Über die Gattung *Mamiania.* Ann. Myc. **16:** 101, 102. 1918.
9. **Lindau, G.** in E. & P. Nat. Pfl. I. **1:** 421–423. 1897.
10. **Magnus, P.** Sur le dénomination botanique des espèces du genre *Laestadia* Awd. 1869. Bull. Soc. Myc. Fr. **9:** 174. 1893.
11. **Petrak, F.** [Mykologische Notizen.] 100. Über *Guignardia Steppani* Petr. Ann. Myc. **19:** 110–112. 1921.
12. ——. [Mykologische Notizen.] 235. *Phomatospora Filarszkyi* n. spec. Ann. Myc. **21:** 241, 242. 1923.
13. ——. [Mykologische Notizen.] 331. *Phomatospora moravica* n. spec. Ann. Myc. **22:** 55–57. 1924.
14. **Potebnia, A.** [Beiträge zur Micromycetenflora Mittel-Russlands.] Gnomoniaceae und Clypeosphaeriaceae. Ann. Myc. **8:** 53–56. 1910.
15. **Rabenhorst, H.** *Carlia* Rab. Flora **40:** 382. 1857.
16. **Reddick, Donald.** The black rot disease of grapes. New York Agr. Exp. Sta. (Cornell) Bull. 293. 1911.
17. **Saccardo, P.** Nuov. Giorn. Bot. Ital. **7:** 306. 1875.
18. —— **& Penzig, O.** Icones Fungorum Javanicorum. *pl. 1–80.* Leiden 1904.
19. **Sydow, H. & P.** [Mykologische Mitteilungen.] Nochmals zur Nomenklaturfrage von *Sphaerella-Mycosphaerella* und einigen andern Gattungen. Ann. Myc. **17:** 44–47. 1919.
20. **Viala, P. & Ravaz, L.** Sur la dénomination botanique (*Guignardia Bidwellii*) du Black-Rot. Bull. Soc. Myc. Fr. **8:** 63. 1892.

EXPLANATION OF FIGURES

Fig. 1. *Mamiania Alni:* photomicrograph of cross section of stroma with the single perithecium. This does not include the entire length of the beak. Fig. 2 shows the stromata on the under side of the alder leaf. Fig. 3 is an enlargement of the filiform beaks.

Fig. 4. *Sphaerognomonia carpinea:* photomicrograph of cross section of leaf with a single stroma. The meristematic layer above the asci, which will become the ostiole, shows very plainly.

Fig. 5. *Gnomoniella georgiana:* photomicrograph of cross section of a perithecium. The arrangement of the asci is typical of the Diaporthaceae.

Fig. 6. *Acrospermoides subulata:* photomicrograph of section of perithecium. Fig. 7 is a greater enlargement showing the paraphysoids.

Fig. 8. *Didymosphaeria Magnoliae:* photomicrograph of cross section of leaf showing perithecium.

Fig. 9. *Ophiodothella leucospila:* photomicrograph of section of perithecium. This is not exactly through the center, so the ostiole through the the clypeus does not show.

Fig. 10. *Guignardia Bumeliae:* photomicrograph of section of perithecium. The stromatic wall here is quite different from the organized one in Fig. 5.

CORDYCEPS SPECIES FROM BRITISH HONDURAS[1]

EDWIN B. MAINS

(WITH 2 FIGURES)

As part of an investigation of the biology of the Maya area of Central America, a co-operative study by the University of Michigan and the Carnegie Institution of Washington, the writer and C. L. Lundell spent the summer of 1936 in an investigation of the flora of the El Cayo District of British Honduras.[2] The first part of the trip was spent south of the town of El Cayo, mostly at the mahogany camps of Valentin and Cohune Ridge. Short trips were also taken to Retiro and Chalillo Crossing. This area is covered with a luxuriant rain forest. The second portion of the trip was spent in the Mountain Pine Ridge, an area where pine and grasses predominate. Among the fungi collected were a number of interesting species of *Cordyceps* all from the Valentin area. These collections and one received from W. A. Schipp are described and discussed in this paper. Other than the specimen obtained by Mr. Schipp the collections were made by the writer and all are deposited in the Herbarium of the University of Michigan.

CORDYCEPS AMAZONICA P. Henn.

Clavae capitate, 1–2 cm. long, the heads ovoid, 3.5 × 3 mm., chestnut-brown, rough from the ostioles, the stipes 1 mm. thick, ochraceous; perithecia ovoid, immersed except for the apices; asci cylindric, 180–210 × 4 μ; ascospores filiform nearly as long as the asci, multiseptate breaking into one celled fragments, 6–16 × 1 μ (FIG. 1: *A, B*).

On cockroaches, Retiro, June 30, 1936 (*3688*); Cohune Ridge, July 13, 1936 (*3838*).

Cordyceps Blattae described by Petch (**8**) on cockroaches dif-

[1] Papers from the Department of Botany and the Herbarium of the University of Michigan.

[2] This expedition was aided by funds from the Horace H. Rackham School of Graduate Studies of the University of Michigan.

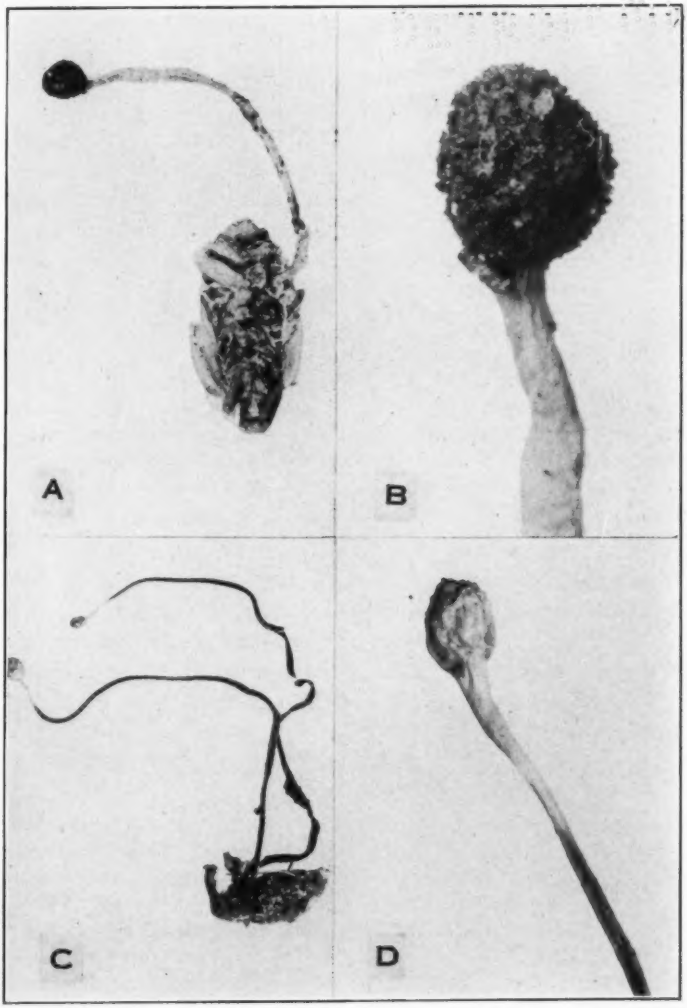


FIG. 1. *A, Cordyceps amazonica* on cockroach, × 2; *B,* head of *C. amazonica* showing ostioles of embedded perithecia, × 10; *C, Cordyceys curculionum* on curculio beetle, × 2; *D,* portion of clava of *C. curculionum* showing bicolored stipe, × 7.

fers in a number of important respects, specially in having clavate asci and fusoid ascospores. The specimens from British Honduras agree very well with the description given by Hennings (3) for *Cordyceps amazonica* on *Locusta* from Brazil. Petch (10) considers *C. amazonica* the same as *C. locustiphila,* a species also described by Hennings (3) for Locusta from Brazil. However, both Hennings and Petch describe the fertile portion of the clavae of *C. locustiphila* as clavate and it would appear doubtful whether the two are the same species.

CORDYCEPS CURCULIONUM (Tul.) Sacc.

Clavae arising between the head and thorax, 4–4.5 cm. long, capitate, the heads ovoid, 1.5–2 × 1–1.5 mm., smooth when fresh except for the slightly projecting ostioles, longitudinally irregularly rugose when dried, pinkish-cinnamon when fresh, the stipes 0.5–1.0 mm. thick, black except for 0.5 cm. beneath the head which is concolorous with the head; asci and ascospores not seen (FIG. 1: *C, D*).

On adult curculio beetle, Valentin, June 29, 1936 (*3683*).

Although the specimen is immature and data concerning the asci and ascospores are not available, there is no reason for doubting the identity of this specimen. The host and the bicolored clavae distinguish the species. It has been reported a number of times from South America. This is apparently the first report from North America.

CORDYCEPS ELONGATA Petch.

Clava bittersweet-orange (Ridgway) when fresh, very slender, 5 cm. long, the stipe 0.8–1.0 mm. thick, yellowish below, brownish-red above (dried), the fertile portion fusoid-clavate, 6 mm. long, 1.5 mm. thick; perithecia reddish-brown, embedded for ½ or ⅔ of their height in a soft, orange stroma which shrinks on drying, ovoid, 250–300 × 200 μ; asci cylindric, 250–300 × 4–6 μ; ascospores filiform, nearly as long as the asci; breaking into segments 4 × 0.5 μ.

On larva of a lepidopterous insect in a cocoon, Valentin, July 6, 1936 (*3766*).

This species was described by Petch (11) from specimens collected in Maine and North Carolina. The specimen from British

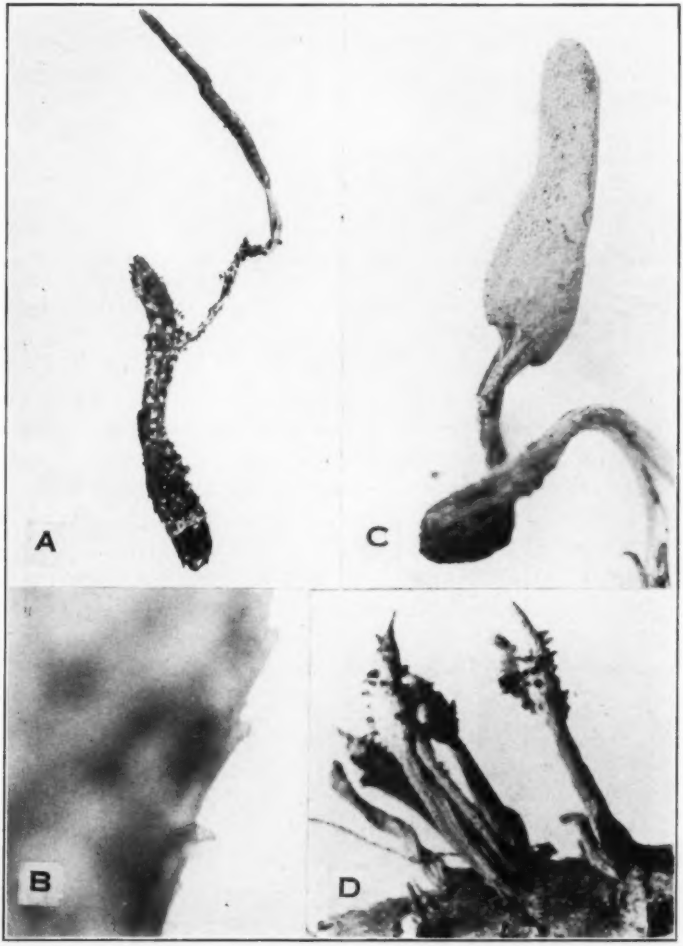


FIG. 2. *A, Cordyceps submilitaris* on larva of a beetle, × 1.5; *B,* portion of clava of *C. submilitaris* considerably enlarged showing upward projecting ostioles of the oblique perithecia; *C, Cordyceps belizensis,* head and upper portion of the stipe, × 2; *D,* clavae of *C. Sphingum* developing from between segments of the abdomen of a moth, × 4.5.

Honduras agrees very well except that the perithecia and asci are somewhat smaller. *C. elongata* resembles *C. militaris* in that the perithecia are partially embedded in a soft stroma. The very slender clavae distinguish it.

CORDYCEPS SUBMILITARIS P. Henn.

Clavae brownish-red, cylindric with acute apices, 2–3 cm. long, attached to hosts by orange rhizomorphs, the fertile portion of the clavae 10–25 × 2 mm., the stipes 1–1.5 mm. thick; perithecia flattened ovoid or flasked-shaped narrowing to the acute apices, obliquely embedded, pointing upward, the apices projecting; asci cylindric 300–420 × 3–4 μ; ascospores filiform nearly as long as the asci, 0.5 μ wide, obscurely septate, the cells 2–4 μ long (FIG. 2: *A, B*).

On large larvae of beetles in rotten logs, Retiro, June 30, 1936 (*3686*); Cohune Ridge, July 13, 1936 (*3836*).

This conspicuous species occurs in herbaria under the names, *C. submilitaris, C. martialis* Speg., *C. Lunti* Giard (error for *C. Hunti* Giard **10**) *C. rubra* A. Möll., and *C. Klenei* Pat. It apparently is a fairly common species of the American tropics.

The larvae are mostly covered with a felt of orange mycelium. The clavae are connected to the larvae by orange rhizomorphs. The clavae vary considerably. As many as six may arise from a larva and in some specimens they reach a length of 5.5 cm. The oblique arrangement of the perithecia is an important diagnostic character.

Whether all the above names should apply is difficult to determine. The earliest name is *C. martialis* published in 1889. Spegazzini (**12**) describes the perithecia as globulose and makes no mention of an oblique arrangement. Giard (**1**) also does not describe an oblique arrangement for *C. Hunti* which was published in 1895. *Cordyceps submilitaris* was published by P. Hennings (**2**) in 1896 based on a specimen collected by Möller in Brazil. Although Hennings does not describe an oblique arrangement Möller (**6**) states that the perithecia are so arranged. Möller (**6**) in 1901 described *Cordyceps rubra* with oblique perithecia and this is apparently the same as *C. submilitaris.* Patouillard (**7**) described *C. Klenei* in 1908. His illustration does not indicate an

oblique arrangement of perithecia. Petch (**9**) has pointed out that in cross sections of the clavae, oblique perithecia would appear globose and decides that the name *C. martialis* should apply. However until this can be substantiated it seems best to employ the name *C. submilitaris*.

Cordyceps belizensis sp. nov.

Clava ochracea, 10 cm. longa, capitulo anguste ovoideo, 20 × 9 mm., stipite 2–3 mm. crasso; peritheciis immersis, ovoideis, 480–570 × 260–300 μ; ascis cylindriceis, 260–300 × 6 μ; ascosporis filiformibus; articulis ascosporarum 4–8 × 1.5 μ (FIG. 2: *C*).

In larva lepidopterae, Retiro, British Honduras, VI, 30, 1936, E. B. Mains (*3687*).

In the dried specimen the clava is ochraceous. When fresh, the head was antimony-yellow (Ridgway) and the stipe was straw-yellow (Ridgway) stained with red. The head is sharply differentiated from the stipe. It is widest below, narrowing somewhat upward to the obtuse apex. The perithecia are entirely immersed in the stroma which entirely covers the head.

CORDYCEPS SPHINGUM (Tul.) Berk. & Curt.

Clavae numerous from various parts of the body of a moth, soft, 7–11 mm. long, the stipes light brown, 0.5–1.0 mm. thick, the fertile portion swelling to 1.5–2.0 mm., whitish, the apices acute; perithecia chestnut-brown, mostly superficial, free, narrowly ovoid, somewhat flattened laterally, 480–540 × 180–250 μ; asci cylindric, 300–360 × 4 μ; ascospores filiform, nearly as long as the asci; breaking into segments 4 × 0.5–1.0 μ (FIG. 2: *D*).

On mature sphinx moth, Camp 36, British Honduras-Guatemala Border Survey, July 15, 1936, W. A. Schipp (*S959*).

This is a very variable species and consequently it has been described under a number of names (**5**). Sometimes clavae are not formed and the perithecia develop on the mycelial covering of the moth. It is a fairly common species in the tropics and has been collected as far north as New Hampshire.

CORDYCEPS VIPERINA Mains

A specimen of this species collected at Cohune Ridge has been reported and described elsewhere (**4**). It has also been collected in Nova Scotia, Ontario, New York, and Tennessee.

LITERATURE CITED

1. **Giard, A.** Une nouvelle espece d'Entomophyte, *Cordyceps Hunti* n. sp. (Champignon) parasite d'une larve d'Elateride. Ann. Soc. Ent. France **64**: 181–182. 1895.
2. **Hennings, P.** Beiträge zur Pilzflora Sudamerika. II. Hedwigia **36**: 190–246. 1897.
3. ——. Fungi amazonica II a cl. Ernesto Ule collecti. Hedwigia **43**: 242–273. 1904.
4. **Mains, E. B.** A new species of *Cordyceps* with notes concerning other species. Mycologia **29**: 674–677. 1937.
5. ——. *Cordyceps* from the mountains of North Carolina and Tennessee. Jour. Elisha Mitchell Sci. Soc. **55**: 117–129. 1939.
6. **Möller, A.** Botanische Mittheilungen aus den Tropen. Phycomyceten und Ascomyceten. **9**: 1–319. 1901.
7. **Patouillard, N.** Quelques champignons de l'Annam. Bull. Soc. Myc. France. **25**: 1–12. 1909.
8. **Petch, T.** Studies in entomogenous fungi. IV. Some Ceylon *Cordyceps*. Trans. British Myc. Soc. **10**: 28–45. 1924.
9. ——. Notes on entomogenous fungi. Trans. British Myc. Soc. **18**: 48–75. 1933.
10. ——. Notes on entomogenous fungi. Trans. British Myc. Soc. **19**: 161–194. 1934.
11. ——. Notes on entomogenous fungi. Trans. British Myc. Soc. **21**: 34–67. 1937.
12. **Spegazzini, C.** Fungi Puiggariana. Bol. Acad. Nac. Ci. Cordoba. **11**: 1–244. 1889.

A NEW FORM GENUS OF THE MONILIACEAE

DONALD P. LIMBER [1]

(WITH 2 FIGURES)

A fungus which, when examined under a hand lens, appeared to belong to the form genus *Verticillium* was found on the dead roots of a plant of *Yucca Treculeana* that was of Cuban origin. More detailed study quickly showed the fungus to be distinct. The conidia-bearing branches had a zigzag appearance under low magnification. Under higher magnification they were seen to be similar in form to the rachis of a wheat spike. In this respect the fungus somewhat resembles *Polythrincium Trifolii* Schmidt & Kunze as described by Wolf.[2] Lacking a perfect stage, its bright yellowish conidiophores and mycelium place it in the form family Moniliaceae and the verticillate habit of the conidiophores assigns it to the tribe Verticilliae. A search of the literature for a verticillate, moniliaceous fungus, bearing conidia on the peculiar zigzag conidiophores described, was unrewarded until our attention was called by Miss Vera K. Charles to a fungus described by Ferraris [3] under the binomial *Sporotrichum flavicans* Fries var. *spicatum* Ferraris. This fungus differs from the one under discussion in that it is described and illustrated with conidiophores bearing only a single whorl of branches. We have been unable to secure a specimen of Ferraris' fungus. It was possible, however,

[1] Grateful acknowledgment is made to Miss Edith K. Cash of the Division of Mycology and Disease Survey, Bureau of Plant Industry, U. S. Department of Agriculture, who contributed the Latin diagnoses; to Miss Vera K. Charles of the same division for assistance in the search of literature; to Dr. Charles Thom of the Division of Soil Microbiology, B. P. I., for the fungus described under the name *T. album;* and to Mr. John A. Stevenson of the Division of Mycology and Disease Survey, B. P. I., for constructive criticism and assistance throughout the work reported.

[2] Wolf, Frederick A. Morphology of *Polythrincium* causing sooty blotch of clover. Mycologia **27**: 58–73. illus. 1935.

[3] Ferraris, T. Ann. Myc. **10**: 295. illus. 1912. Also in: Flora Italica Cryptogama Fasc. **10**: 671–672. illus. 1913.

to grow our fungus on the underside of a cork which was placed in the mouth of a flask of picric acid, thus duplicating the substratum on which *S. flavicans* var. *spicatum* was first found. Under these conditions our fungus did not revert to the simpler type of branching described by Ferraris. It seems best, therefore, to describe the fungus isolated from *Yucca* root as a distinct species.

Though Ferraris described his fungus as a variety of *S. flavicans* it seems clear that he recognized that *S. flavicans* var. *spicatum* bore conidiophores of a form differing from those of the form genus *Sporotrichum* Link. He states, "Curious for the origin of the conidia and the formation of the conidiferous spike. The first conidium is formed at the apex. Below this is formed another branch which bears another conidium somewhat higher up. Thus the first becomes lateral, then there is another branch which extends in an opposite direction, and so always runs alternately, forming a sympodial ramification in the highly regular ensemble. The axis of the spike is accordingly tortuous as if bent zigzag, and is sometimes quite long." [4]

After the *Yucca* fungus had been under study for about three years, it was our good fortune to receive, through the kindness of Dr. Charles Thom, a similar fungus showing differences of only specific value. On the basis of these fungi and *Sporotrichum flavicans* Fries var. *spicatum* Ferraris, the latter of which quite evidently is more closely related to the first two in form than to the genus *Sporotrichum* and should be transferred to the *Verticilliae*, we propose the new form genus as described below:

Tritirachium [5] gen. nov.

Mycelium hyaline or dilutely colored, branched, septate, sinuous, slender; conidiophores long, erect or recumbent, septate, verticillately branched (irregular branching may occur on unfavorable substratum), sometimes biverticillate or triverticillately branched, apical branches slightly subulate at the base and tapering to the rachis-like or zigzag conidia-bearing portion; conidia acropleurogenous, globose to ovate, hyaline or dilutely colored, often conglutinate.

[4] Translation from the Italian by Mr. C. R. Sage, specialist in the translation of foreign languages.

[5] The name is based on the resemblance in form of the conidiophore tips to the rachis of *Triticum*.

Mycelio hyalino vel pallide flavidulo, ramoso flexuoso, parce septato; conidiophoris longis, erectis vel procumbentibus, septatis, verticillatim ramosis, vel bis vel ter verticillatim ramosis; ramis apicalibus subulatis, alternate in forme rachidis vel "zigzag" ordinatis; conidis acropleurogenis globosis vel ovatis, hyalinis vel pallide flavis saepe conglutinatis.

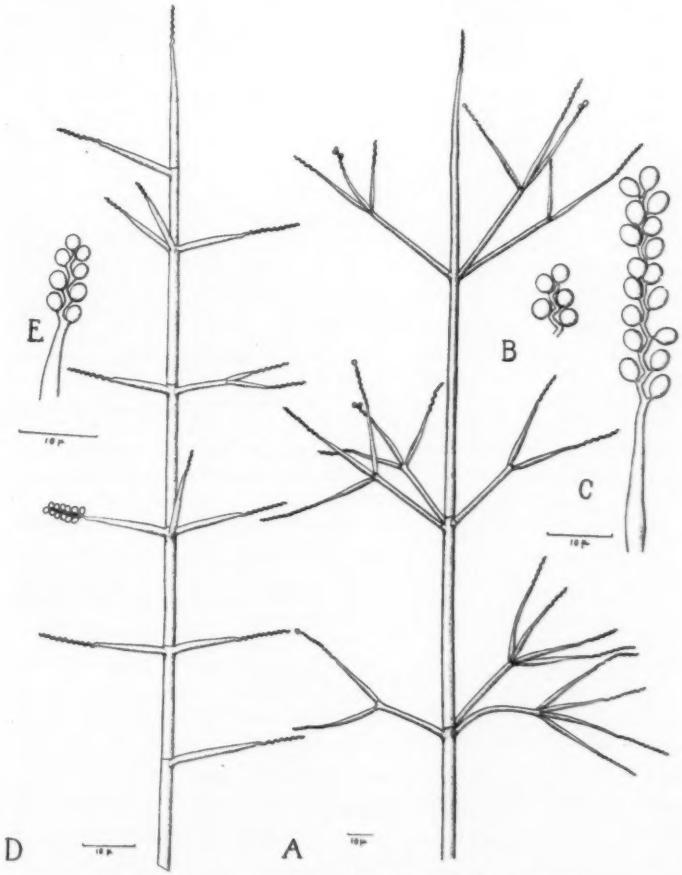


FIG. 1. *A–C, Tritirachium dependens; D, E, T. album.*

The members of this form genus are readily distinguished from other members of the Moniliaceae by the zigzag form of the fertile portion of the conidiophore (FIG. 2, *A, B*).

Tritirachium dependens[6] sp. nov.

Mycelium pale-yellowish to brownish-yellow, branched septate; conidiophores long, stiffly upright, septate, 2.5–4.8 $\mu \times$ 600–900 μ,[7] verticillately branched; 5–10 whorls of branches, mostly 5; branches in primary whorl 2 or 3, mostly 3, primary branches usually branch giving a secondary verticil of 2–4 branches; secondary branches occasionally branch giving a tertiary verticil; conidiophores and branches cylindric except the terminal branches, these slightly swollen near the base and tapering to the first conidia, from the first conidia to the tip zigzag (FIG. 1, *A*); a definite spiral can sometimes be detected in young conidiophore tips bearing three or four spores; conidia acropleurogenous, globose to slightly ovate, pale-yellow, smooth, 2.1–3.3 $\mu \times$ 2.8–3.6 μ, soon cut off, but under favorable conditions spores cohere and may form a club-like mass covering the conidiophore branch or may, on falling away, collect in the axil of the verticil.

Mycelio pallide flavido, ramoso, septato; conidiophoris longis, rigide erectis, septatis, verticillatim ramosis, 2.5–4.8 μ in diam., 600–900 μ longis, verticillis primariorum ramorum 5–10, fere 5, praeditis; ramis primariis plerumque verticillum secundarium ramulorum 2–4, et ramulis secundariis interdum verticillum tertiarum gerentibus; conidiophoris et ramis cylindraceis, ramulis spicalibus ad basim subulatis; alternate in forma rachidis vel spiraliter ordinatis; conidiis acropleurogenis, globosis vel aliquanto ovalis, pallide flavis, 2.1–3.3 $\mu \times$ 2.8–3.6 μ, mox abscissis, saepe circum conidiophorum vel in axe verticilli conglutinatis.

Hab. in radicibus *Yuccae Treculeanae*, in Cuba, cum *Penicillio* consociatus.

Type and dried culture deposited in the Mycological Collections of the Bureau of Plant Industry. This specimen is also designated as the type for the genus *Tritirachium*.

CULTURAL CHARACTERS

The conidia germinate slowly in agar media. Six to seven days elapse before a single spore colony becomes visible to the unaided eye. Growth on such common media as potato dextrose, corn meal, or lima bean agar is restricted, and in some cultures it is definitely of the starvation type with the aerial growth scant and closely appressed to the surface of the agar. On Thaxter's potato

[6] The name refers to the dependence of this fungus on other fungi for accessory growth substances.

[7] The conidiophore measurements and details are those of the original interception of *Yucca*. On culture media longer conidiophores are found and more complex branching.

dextrose agar a needle streak spreads laterally only 4–5 mm. (FIG. 2, *C*, tube labeled control at right). On corn meal agar a needle streak attains a width of 2–3 mm. The color of the aerial growth is "vinaceous fawn" to "avellaneous."[8] Thaxter's potato dextrose agar, used as the substratum, takes on a red color, shading from "garnet brown" to maroon beneath the center of the colony, after prolonged growth of the fungus; when corn meal agar is used, it becomes slightly pink.

Subaerial conidia may be found in cultures grown on corn meal agar. These may occur sparsely, in which case the conidia are few in number on the zigzag branch (1–3) and normal in size; or abundantly. In this case the conidia-bearing portion of the branches resembles a raceme (FIG. 1, *C*) due to the less crowded arrangement of the conidia and the fact that they are here borne on short sterigma or stalks measuring about 1 μ long; the conidia are larger, measuring up to 2.3–4 $\mu \times$ 3.2–4.5 μ and are more ovate in shape than the aerial conidia.

Tritirachium album sp. nov.

Mycelium hyaline, tortuous, septate, sparingly branched, branches usually near septa, 1–2 μ in diameter, conidiophores erect, or recumbent with age, branched, branches usually in whorls of 2–4, occasionally biverticillate with 2–3 branches in secondary verticil, fertile branches short, forming a 70°–90° angle with the conidiophore, sterile portion cylindric to subulate, fertile region zigzag; conidia hyaline, globose or ovate, 1.6–2.5 $\mu \times$ 1.7–3.2 μ (based on 60 measurements).

Mycelio hyalino, tortuoso, septato, parce ramoso, ramis plerumque prope septum, 1–2 μ in diam., conidiophoris rectis vel in maturitate recumbentibus, 2–4 verticilliter ramosis, ramis fertilibus brevibus, parte sterili cylindrica usque subulata, parte fertili "zigzag"; conidiis hyalinis, globosis vel ovatis, 1.6–2.5 $\mu \times$ 1.7–3.2 μ

Dried culture deposited in the Mycological Collections of the Bureau of Plant Industry.

[8] Color readings in quotation marks are based on Ridgway. Ridgway, R. Color standards and color nomenclature. 43 pp. Washington, D. C. illus. 1912.

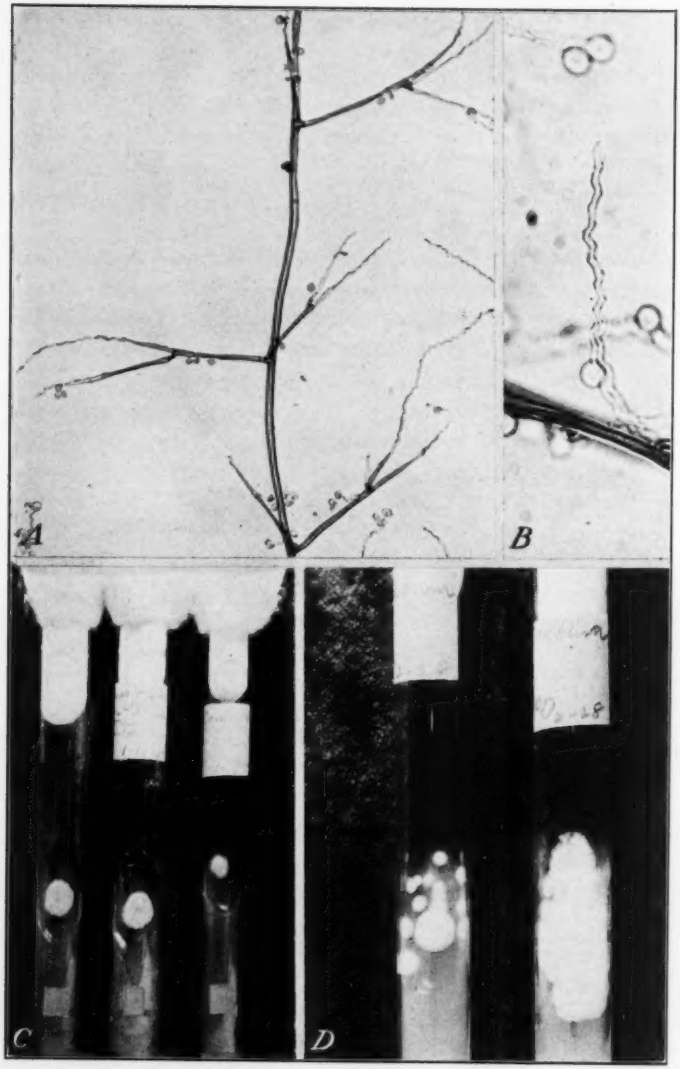


FIG. 2. *A–C, Tritirachium dependens; D, T. album.*

CULTURAL CHARACTERS

Mycelial mat pure white, forming a low dome or hemisphere, densely matted, covering substrate if moisture conditions remain favorable, surface cottony, margin regular. On Czapek's agar the conidiophores are quite uniformly verticillate (FIG. 1, *D*) with numerous whorls of short and, usually, simple branches. The color of the substrate on this medium is "orange." On Thaxter's potato dextrose agar vegetative growth is encouraged at the expense of spore production and less regularity is found in the verticillate character of the conidiophores. Fifty per cent of the whorls may be represented by solitary branches. On this medium the color of the substrate is "orange."

This species was received in pure culture from Dr. Charles Thom as acknowledged above. It was separated by Dr. Thom from a colony of *Penicillium intricatum* Thom and was thought to be a contaminant. Dr. Thom received the material from Oscar W. Richards of the Spencer Lens Co., Buffalo, N. Y., who informed the writer that the collection "was taken from a book" in the basement of the Marine Biological Laboratory, Woods Hole, Mass., in 1937. A brief description of this habitat is given by Richards and Hawley.[9] But the reader is cautioned that, as *T. album* was probably a contaminant of the *Penicillium* culture, it may have entered the culture at a later date and be of quite different origin. It is perhaps noteworthy that both this species and *Tritirachium dependens* were found associated with species of *Penicillium*.

SPOROTRICHUM FLAVICANS FRIES VAR. SPICATUM FERRARIS

This fungus is described and illustrated by T. Ferraris as having verticillately branched conidiophores, and zigzag conidiophore tips. As noted above, it resembles *T. dependens* so closely as to suggest identity. As *S. flavicans* var. *spicatum* is not available for study, we are forced to accept the difference in their conidiophore branching, that is, a single whorl of branches, some of which may be forked, for *S. flavicans* var. *spicatum;* whereas *T. dependens* shows many whorls with secondary and tertiary division of the

[9] Richards, Oscar W., & Hawley, K. J. Mold elimination in marine laboratories. Jour. Chem. Educ. **16**: 6–10. 1936.

branches, as a specific difference. We would assign *Sporotrichum flavicans* Fries var. *spicatum* Ferraris to the new form genus *Tritirachium*.

Tritirachium spicatum (Ferraris) comb. nov.

Sporotrichum flavicans Fries var. *spicatum* Ferraris.

BUREAU ENTOMOLOGY AND PLANT QUARANTINE,
WASHINGTON, D. C.

EXPLANATION OF FIGURES

Fig. 1, *A–C. Tritirachium dependens: A,* conidiophore; *B,* conidia on conidiophore; *C,* subaerial conidia; *D–E, Tritirachium album: D,* conidiophore; *E,* conidia attached.

Fig. 2, *A–C. Tritirachium dependens: A,* portion of conidiophore with branches; *B,* conidiophore tip under higher magnification; *C,* tube labeled "control" shows normal restricted growth on Thaxter's potato dextrose agar; the tubes at the left received additions of growth accessory nature and show a decided response; *D, Tritirachium album;* tube at left on synthetic media, tube at right on Thaxter's potato dextrose agar. Photomicrographs by Marcel L. F. Foubert.

DEVELOPMENT OF GASTERELLA LUTOPHILA

LEVA B. WALKER [1]

(WITH 45 FIGURES)

Gasterella lutophila was described by S. M. Zeller and Walker [2] from an initial collection of the fungus that had developed upon the surface of saturated woodland loess soil in a greenhouse, during very hot weather. At the suggestion of Dr. Zeller the source of the soil was traced and, as indicated in a note appended to the published paper, abundant additional materials were secured after the paper was in the hands of the publisher. Since then many soil collections from the same region have been obtained during various seasons, and in all cases (except one collection) *Gasterella* appeared in just three weeks after the soil had been saturated, covered and placed under growing conditions. Soil from this region, on one occasion, was stored dry during the entire summer in a third floor room where the temperatures were near or above 100° F. throughout an especially hot, dry summer. Upon saturation in the fall *Gasterella* appeared as usual. These later cultures have furnished quantities of materials for study. Soils from other regions that have been tested by the writer have never developed the fungus.[3]

In spite of the fact that *Gasterella* seems to be so abundantly present in these loess soils the writer or seemingly no one else has been able to find the fungus in its natural habitat. Whether it is epi- or hypogeous in nature is uncertain. Attempts to determine experimentally this point yielded inconclusive evidence. Where

[1] Contribution No. *116* from the Department of Botany, University of Nebraska.

[2] Zeller, S. M., and Leva B. Walker. *Gasterella*, a new uniloculate Gasteromycete. Mycologia **27**: 573–579, 13 figs. 1935.

[3] Mr. John B. Routien of Mich. Agr. College writes me he has secured *Gasterella* from several locations in Michigan. A slide sent me agrees perfectly with the original materials studied. His cultures were made during the summer.

the surface of the soil was much roughened the basidiocarps usually appeared most abundantly on the sides of elevations where water stood at the base but in no case where tunnels were made did they become lined with basidiocarps. Light seemed to have little or no effect upon their development. The basidiocarps only developed on saturated soil where the air was saturated also. For this reason it seems probable that in nature these conditions would most readily occur in hollows and burrows such as are characteristic for *Protogaster*.[4]

Many attempts have been made to secure pure cultures of the fungus but spore germination has never been secured and all other efforts have failed. Occasionally bits of soil upon which the young basidiocarps were just beginning to appear gave rise to new growth when transferred to sterilized soil but even this method of propagation was not dependable.

The first evidence of developing basidiocarps of *Gasterella* is the appearance of tiny tufts of radiating hyphae on the surface of the saturated soil. These tufts enlarge rapidly and within a day or two take on the form of the mature fruit-body. New basidiocarps appear during the next few days but after this brief period additional ones rarely develop.[5] The fruit-bodies when young are snowy white but in a few days they become ashy gray as the darkening spores show through the delicate peridium. When old the walls of the basidiocarps collapse and the fruit-bodies appear under a hand lens much like tiny black cup fungi.

These studies are based upon materials taken from vigorously growing cultures and fixed largely in formol-acetic-alcohol solutions,[6] as these seemed to give the best results. The fixed materials were imbedded in paraffin and sectioned in the usual manner. The most satisfactory stain used for sections was Heidenhain's iron-alum-haematoxylin counterstained with Orange G in clove oil.

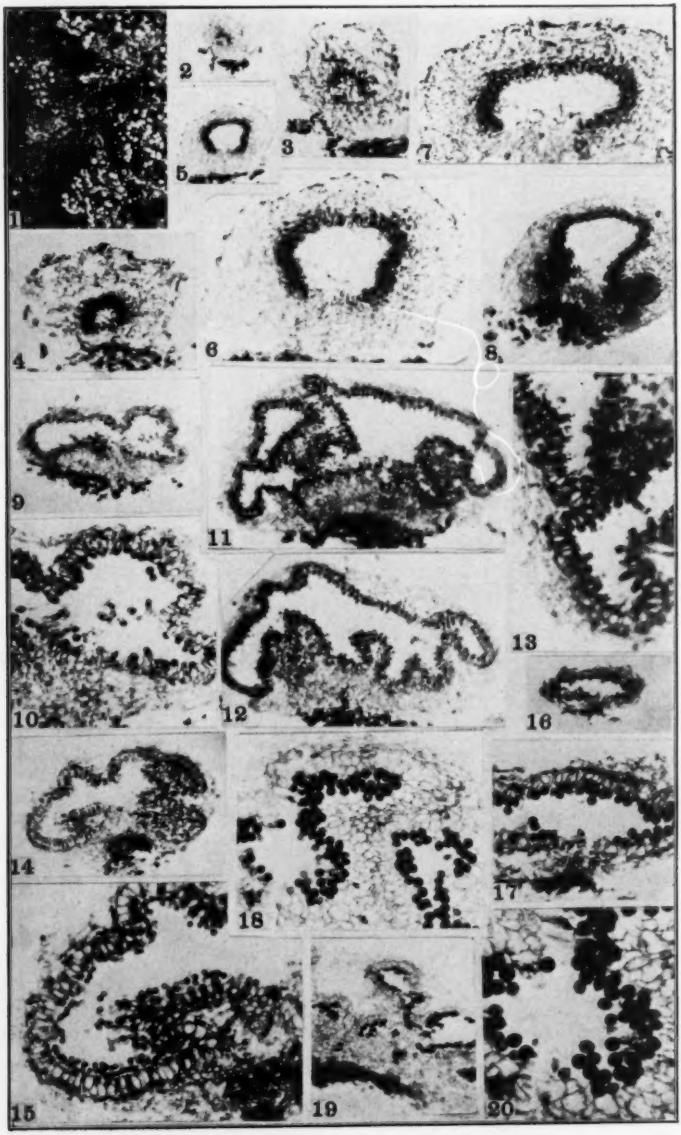
[4] Zeller, S. M. *Protogaster*, representing a new order of Gasteromycetes, Ann. Missouri Bot. Gard. **21**: 231–240. 1934.

[5] In the original collection the fact that new basidiocarps failed to develop was erroneously attributed to the very hot weather since all subsequent cultures have behaved similarly.

[6] The two formulae used most are (*a*) neutral formalin 10 cc., glacial acetic acid 5 cc., and 50 per cent alcohol 100 cc., and (*b*) neutral formalin 6 cc., glacial acetic acid 1 cc., and 50 per cent alcohol 93 cc.

ORIGIN AND DEVELOPMENT OF BASIDIOCARP

As previously noted, the first appearance of a basidiocarp is the appearance of a tiny tuft of hyphae which radiate from a tangle of hyphae. The youngest of these knots sectioned is shown in figure 2 and more highly magnified in figures 3 and 21. In this as well as other young stages the radiating superficial hyphae are disarranged and intertangled from handling. The first differentiation in the hyphal mass is the appearance of downward growing hyphal tips which form a palisade layer in the upper part of the young knot. This layer is interrupted by undifferentiated primordial hyphae that extend from tip to base through a chamber that is being formed by the expansion due to the developing palisade layer and resultant breaking of the primordial tissue below. Figure 21 is a diagrammatic drawing of this basidiocarp and figure 22 shows a portion of this palisade layer enlarged. The hyphae making up the young basidiocarp are binucleate. Many basidiocarps only slightly older than this one were observed, three of which are shown in figures 4, 5–7, 23–24. As is evident from these figures, the palisade layer broadens laterally and extends downward lining the sides of the enlarging chamber. The individual cells of this expanding palisade layer are enlarging and some appear definitely to be young basidia. At the base of the young basidiocarp the hyphal cells enlarge and coalesce to form a somewhat pseudoparenchymatic base from which hyphae below spread into the substratum. Figure 4, of which all sections were slightly diagonally cut, is probably the next to youngest fruit-body sectioned and shows only a beginning of this pseudoparenchymatic base. The basidiocarp shown in figures 23 and 24 shows clearly the structure when only slightly older. Very often so much dirt is held in this region that it is badly torn or broken away during sectioning. This was true in the fruit-body shown in figures 5–7, where the base is lacking in median sections such as figure 7. Above this pseudoparenchymatic base a few hyphae with scanty protoplasmic content extend out to and through the palisade layer, connecting with the tissue above (FIGS. 23, 24). It is obvious that the palisade-like layer is the young hymenium and that new elements are being added from the meristematic sub-



FIGS. 1–20.

hymenial cells to the outside of this layer. The elements in the hymenium and subhymenium are about twice as large in the basidiocarp shown in figures 23 and 24 as in the very youngest knot, figures 21 and 22. The subhymenium merges into the delicate hyphae that will constitute the peridium.

As new elements are added to the hymenium, it becomes arched upward and the primordial hyphae that originally stretched across the central region become broken and remain only as remnants. In this way the single locule characteristic of the fungus is formed. As the hymenium increases in extent it never entirely closes over the gap at the base of the fruit-body (FIGS. 7, 8, 9, 11, 14). This sterile region is usually quite conspicuous but occasionally it is restricted to a very narrow region as in the fruit-body shown in figures 9 and 10. In the border region, between hymenium and the ruptured primordial hyphae at the base depauperate cells, shaped much like basidia, commonly occur. These may be best observed in slightly tangential sections of basidiocarps (FIGS. 5, 6). In this basidiocarp all basidia are still binucleate.

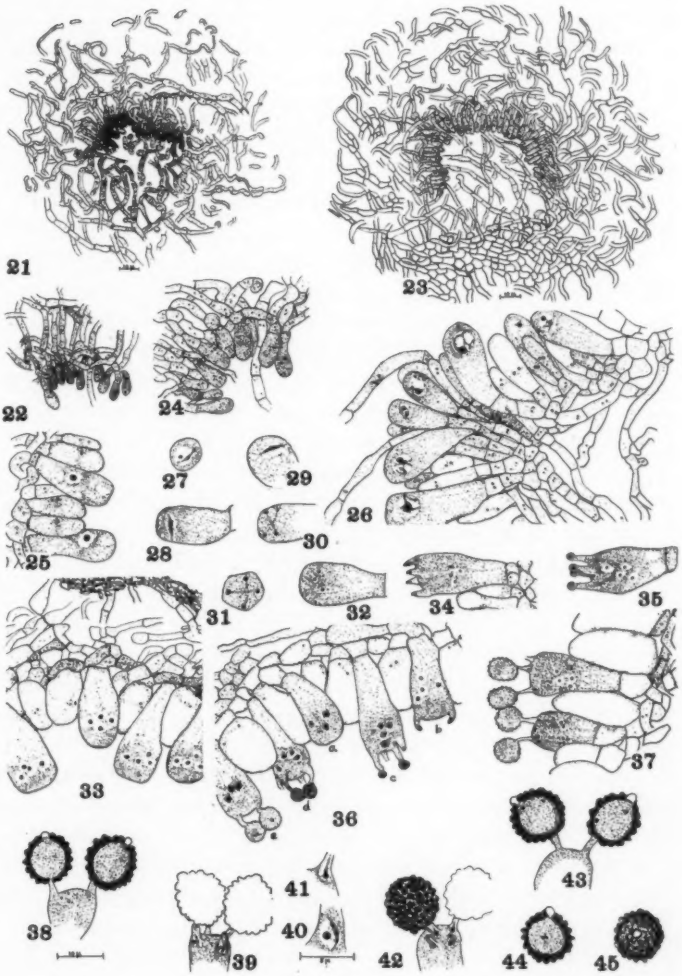
The hymenium seemingly may continue to develop almost indefinitely if growing conditions are favorable or may mature without farther expansion. Very small mature fruit-bodies, formed in exceptionally hot weather, as figures 16 and 17, may show no farther expansion of the hymenium or only a very slight folding at the base. In most of the basidiocarps, however, the hymenium expands so extensively that considerable hymenial folding results. A beginning of this folding is shown in figure 6. Where only slight folding occurs it is usually limited to an area just above the sterile region at the base, figure 8. (Figures 1, 2, and 9 in the published description of *Gasterella* are in reality slightly tangential and not truly vertical sections taken at the point of greatest diameter. The fold at the base was a lateral fold at one side of the sterile base. The sterile region was mistaken for a break in sectioning.) When conditions are very favorable folding may take place from any portion of the hymenium. Basidiocarps with only uninucleate and young binucleate basidia were observed that were as large and as much folded as the one shown in median section in figure 11 and tangential section in figure 12 and in all intermediate types as figures 9–10, 14–15. As the hymenium ex-

pands the peridium stretches out and without modification becomes the delicate cobwebby covering of the mature basidiocarp (FIGS. 9–19). When hymenial expansion ceases the hymenium rapidly matures regardless of the size of the basidiocarp and the extent of folding of the hymenium.

DEVELOPMENT OF THE HYMENIUM

As previously stated, the hymenium has its origin in a palisade-like layer that develops in the upper portion of a primordial knot of hyphae. This layer has its origin from downward growing hyphal branches (FIGS. 21, 22). The slightly enlarged hyphal tips and the hyphae from which they originate are all binucleate and very densely filled with cytoplasm. In a slightly older fruit-body, such as shown in figures 23 and 24, the only notable change is the great increase in the size of the elements forming the hymenium and subhymenium. As the individual elements of the hymenium continue enlargement one can easily distinguish three types of cells (FIG. 25): cells in which the two nuceli previously present have fused, basidia; binucleate celis with scanty cytoplasm and large vacuoles, young paraphyses; and binucleate cells with denser protoplasm which are probably young basidia or which have not at least become definitely specialized. The changes indicated here show more clearly in slightly older basidiocarps such as are illustrated in figure 26. Here the basidia are shown as they appear just before meiosis. The paraphyses still retain a clavate shape much like that of the basidia. In this figure, as well as in figures 22 and 24, the remains of primordial hyphae extending through the hymenium are shown. In later stages they are rarely seen.

Meiosis in the basidia seems entirely normal but no attempt was made to determine the details. Three stages of the first division are shown in figures 27–29 and the telophases of the second division in figures 30 and 31. Following the second division four nuclei are organized (FIGS. 32, 33). By this time the basidia have reached their maximum size and protrude far beyond the paraphyses which have broadened greatly and contain two small nuclei, scanty cytoplasm, and a very large vacuole. In the basidia the basal region is vacuolate and the nuceli and cytoplasm largely con-


21
23
22
24
25
27
29
28
30
26
31
32
34
35
33
36
37
38
41
40
39
42
43
44
45

FIGS. 21–45.

fined to the upper half of the basidium. A basidiocarp at this age is shown in figures 9 and 10.

Soon sterigmata begin to appear, first as tiny elevations containing a deeply staining granule at their tip. They soon reach conditions such as shown in figures 34 and 35. Successive stages as shown in figures 32–35 may often be observed in a single basidiocarp such as the one shown in median and tangential sections in figures 11 and 12. Figure 13 is a higher magnification of the lower lefthand portion of the fruit-body shown in figure 11. Figure 36 shows the details of a portion of the hymenium in this basidiocarp, *a–e* representing successive developmental stages as seen in a small area of hymenium. Echinulations are beginning to appear on the walls of the spores developing at the ends of sterigmata on the oldest basidia in this fruit-body as shown in figure 36, *e*. The development of the sterigmata and spore initials must progress rapidly, because in only slightly older basidiocarps (FIGS. 14, 15) the basidia seem much more uniform in development. The detail of such basidia is shown in figure 37. It is only when the spore-walls are seemingly entirely mature that the nuclei which have been quiescent near or slightly above the center of the basidium move to the upper part of the basidium (FIG. 38). In a number of cases mitosis seemed to occur just as the nucleus entered the basidium, as shown in figure 39 and more highly magnified in figure 440, but very often the nuclei entering the sterigmata appeared as shown in figure 42 and more highly magnified in figure 41. After the passage of the nuclei through the sterigmata two nuclei appear in each spore (FIGS. 43, 44). The basidia soon appear empty and collapse as do the paraphyses also. Figures 18–20 are three magnifications of portions of a large basidiocarp showing these changes. Only rarely can sterigmata be seen. Soon no trace of the hymenial elements, except the spores, remains. A slightly younger, practically mature basidiocarp, such as described in the published paper (l. c.), is shown in figures 16 and 17. The spores have a heavy black wall with a small hyaline apiculus (FIGS. 38, 43–45). Occasionally a spore is observed with a much elongated apiculus as in the lower left portion of figure 20. All basidia are seemingly four-spored.

The description of the development of the basidia given here

differs in many points from that given in the earlier paper (l. c.). A reexamination of the slides made from the original collection upon which that paper was based shows that we had quite adequate justification for the statements made, but that also basidia developing as is here described were undoubtedly present. After seeing stages in the passage of nuclei into the spores and in the spores of actively developing basidiocarps it seems certain that the single nucleus shown in partially matured spores in figure 6 of this paper was not a nucleus but a deeply staining granule, possibly a modification of the granule present at the tip of the sterigma as it developed. Never were nuclei observed in immature spores in the later materials. Many eight-nucleate basidia appeared in the original materials and were occasionally observed in subsequent materials but in all cases there were also evidences of stunted development. It seems probable to the writer that under certain conditions the nuclear division which usually takes place at the base of the sterigma or during the passage of the nucleus through the sterigma might take place earlier and so give rise to eight nuclei in the basidium. In no case could the writer find evidence of the passage of nuclei from such basidia into spores.

In the published paper on *Gasterella* (l. c.) the occurrence of cystidia in basidiocarps was mentioned. These were present in some and entirely absent in others—a point that was not made entirely clear. No cystidia were ever found in the later materials grown in the laboratory where development seemed to be more vigorous. They were, however, present in basidiocarps of the fungus secured by Mr. Routien during last summer in Michigan as previously mentioned. The fact that they may be present or absent in these fruit-bodies developed under unfavorable conditions lends weight to the idea that they may be modified basidia that during abortion have developed in this manner. Figures 16 and 17 are photographs of one of the very typically small basidiocarps that contain these cystidia.

GENERAL CONSIDERATIONS

Since the published paper was based on scanty material and the measurements taken from prepared slides, variations from the original description should be noted. The basidiocarps may attain

a diameter of 1225 μ or possibly larger. The spores from fully matured dry basidiocarps when mounted in 7 per cent KOH are 11–16 $\times$ 13–17 μ including the apiculus and the verrucose warts on the spores. The apiculus is hyaline and usually about 2–3 μ long in fresh material. In herbarium material of old basidiocarps and especially those that have collapsed and look much like tiny black cup fungi the apiculus can not usually be distinguished. It seemingly becomes brown and appears, if visible at all, as an especially large wart. Cystidia are rarely present and were only observed in depauperate basidiocarps developed in very warm weather. The color of the basidiocarps varied from white when young to ashy gray as they mature and inky black in their final stage. Only four-spored basidia were observed.

The extremes of variation observable in *Gasterella,* if seen in different collections, would readily suggest several species, but since every gradation from tiny basidiocarps with a uniform, unfolded hymenium, with or without cystidia, lining the single locule, except for a restricted sterile region above the point of attachment, up to relatively large fruit-bodies with a much folded hymenium were seen, it seems positive that these are variations within a single species. The extremes of variation observed probably indicate great plasticity such as might be expected in a truly primitive form.

In the earlier paper by S. M. Zeller and the writer (l. c.) *Gasterella* was tentatively placed in the Protogastrales and Protogastraceae because both are unilocular. It was, however, pointed out that *Gasterella* differed from *Protogaster* basically in that *Gasterella* has a sterile base with a definite point of attachment which is lacking in *Protogaster* and spores characteristically different in shape and markings and that those of *Gasterella* suggest a relationship to *Hymenogaster.* Fischer,[7] in a reclassification of Gasteromycetes, taking into consideration his own researches and those of others, bases his classification upon the origin of glebal chambers in the development of the basidiocarp. Only studies on mature basidiocarps of *Protogaster* have been possible up to the present. These indicate a locular type of development for *Proto-*

[7] Fischer, Ed. Unterklasse Eubasidii Reihe Gastromyceteae. Engler und Prantl, Die natürlichen Pflanzenfamilien. 2. Auflage, Bd. 7a. 1933.

gaster while the present study shows definitely that in *Gasterella* the early development is campanulate. With these basic differences it seems impossible to place these genera in the same family. It was also previously pointed out that Rehsteiner [8] in his study of *Hymenogaster verrucosus* Bucholtz (*H. Rehsteineri*) found it to be unilocular in its early development but that this condition was soon changed to a multilocular condition by proliferation and the origin of new chambers. The present study shows definitely that in *Gasterella* its early companulate development is essentially like that of *H. verrucosus* but in *Gasterella* development is arrested at this stage so that it permanently has only one glebal chamber even after extensive proliferations of the hymenium have taken place. Thus according to Fischer's interpretation, and especially as discussed in his 1936 paper,[9] *Gasterella* is clearly related to *Hymenogaster*. Because of the characteristics pointed out above, it seems possible that *Gasterella* should be removed from the Protogastrales and placed in the Hymenogastrales as the simplest known genus of the Hymenogastraceae. It may, however, be deemed best to place all simple, unilocular forms together in the Protogastrales, based only on this one characteristic, but in a separate family. This is a problem for the consideration of systematists.

ACKNOWLEDGMENT

The writer is indebted to Dr. S. M. Zeller for reading a first draft of this paper and making suggestions.

DEPARTMENT OF BOTANY
UNIVERSITY OF NEBRASKA
LINCOLN, NEBRASKA

EXPLANATION OF FIGURES

Photograph Figs. 1–20. Fig. 1 by Richard Hufnagle, otherwise by author. Fig. 1, *Gasterella* as it appears on soil slightly magnified; 2, 3, origin of locule by differentiation of palisade layer in upper portion (2 × 50, 3 × 125) (See also figs. 21 and 22); 4, slightly older basidiocarp with binucleate basidia (× 125); 5–7, older basidiocarp with binucleate basidia, 5 and 6, slightly tangential, 7 median (5 × 50, 6 and 7 × 125); 8, median section of

[8] Rehsteiner, H. Beiträge zur Entwicklungsgeschichte der Fruchkörper einiger Gastromyceten. Bot. Zeit. **50**: 764–771. pl. 10 f. 1–6. 1892.

[9] Fischer, Ed. Neue Beiträge zur Kenntnis der Verwandtschaftsverhältnisse der Gastromyceten. Ber. Schweiz. Bot. Ges. **45**: 231–247. 1936.

basidiocarp with many uninucleate basidia—hymenium conspicuously folded above a sterile basal region (× 50); 9–10, median section of basidiocarp with 4 nucleate basidia, some showing beginning of sterigmata—basal sterile region nearly obliterated (9 × 50, 10 × 125); 11–13, median (11) and tangential (12) sections of a typical large basidiocarp showing sterile region at base and types of hymenial folding (× 50)—various stages in the development of sterigmata and spore initials are present (See fig. 36). 13 shows the lower left-hand portion of fig. 11 (× 125); 14, 15, median section of a common type of basidiocarp: the walls of the spores are approaching maturity (14 × 50, 15 × 125); 16, 17, median section of a mature small basidiocarp of the type developed during very hot weather showing lack of folding of hymenium, sterile basal region, and an occasional cystidium in the hymenium (16 × 50, 17 × 125); 18–20, parts of a mature large basidiocarp: 19, part of median section (× 50); 18 and 20 portion of hymenium (18, × 125 and 20, × 200).

Figs. 21–45. Drawing made by aid of camera lucida with Zeiss lenses. Scale as indicated at lower left except figs. 21, 22, 40, 41, where indicated below drawing. Fig. 21, slightly diagrammatic drawing of the very young basidiocarp shown in figs. 2 and 3; 22, detail of palisade layer seen in fig. 21; 23, slightly diagrammatic drawing of a little older basidiocarp; 24, detail of hymenium shown in fig. 23; 25, portion of hymenium with very young uninucleate basidia; 26, portion of hymenium just before meiosis in basidia (shown on margin of hymenial fold); 27–35, successive stages in basidial development; 33, portion of a basidiocarp just before beginning of sterigmatal development to show detail of all regions; 36, portion of hymenium from basidiocarp shown in fig. 13; 37, basidia with half grown spore walls and paraphyses; 38, basidium showing two of four sterigmata and mature spore walls just before passage of nuclei into spores; 39–40, division of nuclei in base of sterigmata; 41–42, passage of nuclei into sterigmata. Mitosis not seen; 43, end of basidium just after passage of nuclei into spores (spores binucleate); 44, typical mature spore with hyaline apiculus; 45, apical view of spore.

A THIRD SPECIES OF MASTIGOSPORIUM ON GRAMINEAE [1]

RODERICK SPRAGUE [2]

(WITH 1 FIGURE)

The commonest leaf spot on *Dactylis glomerata* L. and on *Agrostis* spp. in Oregon was recently shown to be caused by a fungus that the writer has called *Mastigosporium calvum* (Ellis & Davis) Sprague.[3] According to Articles 16 and 60 of the present International Rules of Botanical Nomenclature (1935), varietal names raised to specific rank are not valid when a specific epithet is available. As pointed out by the writer in the previous article,[3] *rubricosa* of *Fusoma rubricosa* Dearn. & Barth. is the oldest species name applied to this fungus. Therefore, **Mastigosporium rubricosum** (Dearn. & Barth.) comb. nov. is the preferred combination. This species, *M. rubricosum,* which has navicular, hyaline spores (FIG. 1, *A*) occurs in both North America and Europe, while a second European species, *M. album* Riess, which has terminal appendages, has not been reported from the western hemisphere. The spore of *M. rubricosum* illustrated in figure 1, *A,* was taken from *Trisetum cernuum* Trin. collected at Bergsvik Creek, Clatsop County, Oregon, March 16, 1939 (O. S. C. No. *417*), on which species of grass this fungus had not been previously reported.

A third species of *Mastigosporium* was found on leaves of *Bromus vulgaris* (Hook.) Shear along Mehl Creek, a small tributary of the Umpqua River in Douglas County, Oregon, February 18 and March 7, 1939. The native host, called narrow-flowered

[1] Cooperative investigations by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and Oregon Agricultural Experiment Station. Published as Technical Paper No. 313 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution of the Department of Botany.

[2] Associate Pathologist, Division of Cereal Corps and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

[3] Sprague, R. Two *Mastigosporium* leaf spots on Gramineae. Jour. Agr. Res. **57**: 287–299. 1938.

brome, is scattered through moist fir woods at moderate altitudes in the Coast and Cascade mountains of the region. The fungus is probably native.

The fungus produces speckled brown lesions which coalesce to form mottled areas along the sides and terminal halves of the

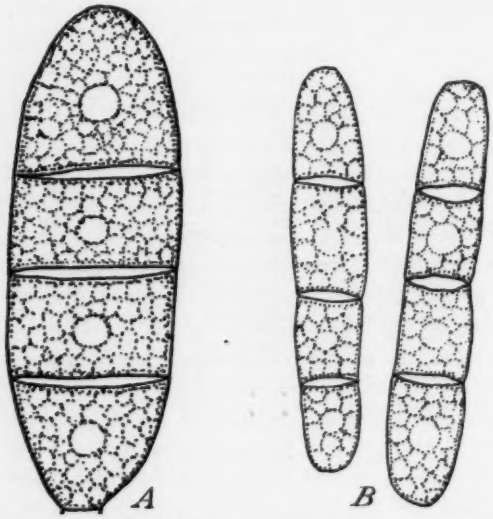


FIG. 1. Conidia of: *A, Mastigosporium rubricosum; B, M. cylindricum,* × 2000.

leaves. The spores, which are not abundant, are capsular, three-septate, hyaline with large nuclei (FIG. 1, *B*). They are not only much smaller than those of *M. rubricosum* but are regularly cylindrical instead of navicular or elliptical. Their manner of developing on stout conidiophores and maturing from the apex down is typical for *Mastigosporium,* however. The fungus appears to be an undescribed species, for which the following name is proposed:

Mastigosporium cylindricum Sprague, sp. nov.

Maculis brunneis, ellipticis, dein confluentibus, myceliis hyalinis, endophytis, septatis, conidiophoris hyalinis, brevibus, conidiis hyalinis, sparsis v. subnumerosis, cylindraceis, (capsularibus) tri-septatis, 25–32 × 4.5–9 μ.

Hab. in foliis vivis *Bromi vulgaris.*

Spots brown, elliptical to elongate, finally confluent and mottled, commonest along the sides and tips of the leaves. Mycelia mostly endophytic, somewhat coalesced beneath the upper leaf surface, coarse, hyaline or lightly tinted, producing short, stout conidiophores which produce the spores by expansion of the distal portion and eventual abscission. Spores straight sided, slightly or scarcely constricted at the septa, cylindrical with rounded, blunt ends, typically capsular, hyaline, 3-septate, 25–32 × 4.5–5.9 μ.

On living leaves of *Bromus vulgaris* (Hook.) Shear in fir woods 600 feet above the Umpqua River along Mehl Creek between Elkton and Kellogg, Douglas County, Oregon, Feb. 18 (O. S. C. No. *488*, Type, FIG. 1, *B*) and March 7, 1939 (Nos. O. S. C. *482–487*). Specimens have been deposited in the herbarium of Oregon State College and in Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture.

CERTAIN NUCLEAR PHENOMENA IN ALBUGO PORTULACAE

RUSSELL B. STEVENS

(WITH 8 FIGURES)

The story of sexual reproduction in *Albugo candida* as worked out by Wager (**6**), Davis (**2**), F. L. Stevens (**5**), and others is well known, involving as it does the formation of oogonia and appressed antheridia within the host tissue. Development of an oogonium is marked by the accumulation of much of the cytoplasm in the central portion of the enlarged hyphal structure, during which process the first mitosis takes place, followed by the differentiation of the contents into a dense homogeneous ooplasm with its well-developed coenocentrum and a vacuolate periplasm. Whether all nuclei pass from the ooplasm and a single one slips back to remain without division (**2**), or whether several nuclei remain in the central ooplasm and after a mitosis all but one migrate to the periplasm (**5**), the end result is the same, namely, a uninucleate oosphere with prominent coenocentrum separated from a vacuolate multinucleate periplasm. At this point a male nucleus derived from the intruding fertilization tube unites with the egg nucleus, and subsequent divisions within the zygote formed give rise to the multinucleate resting oospore.

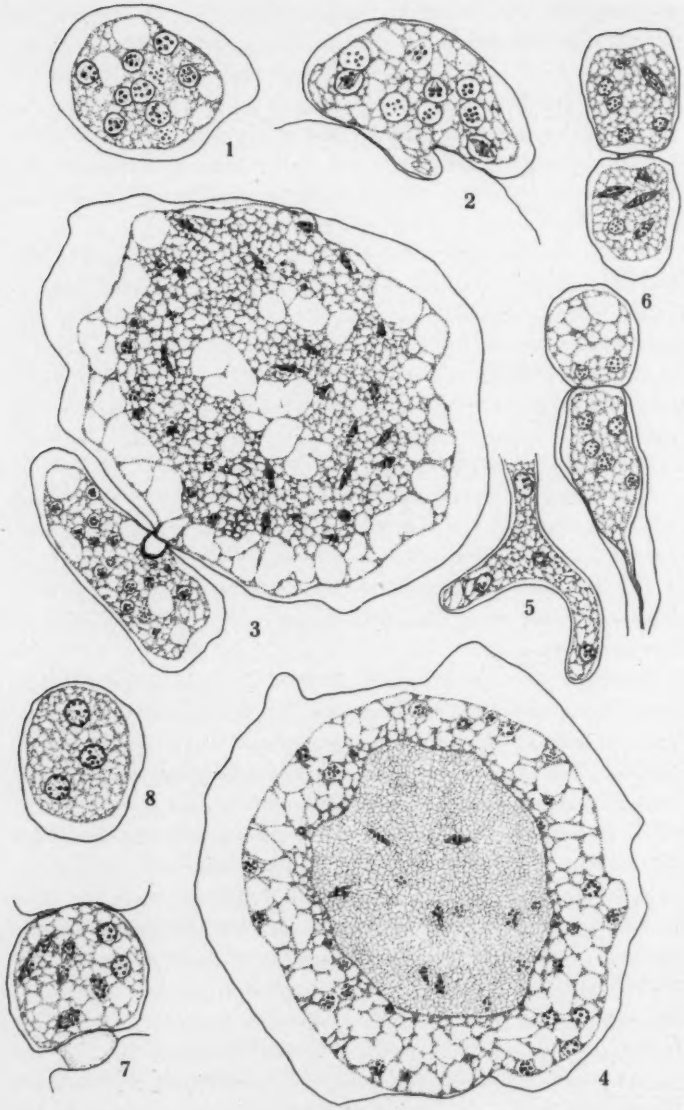
The ontogeny of *Albugo Portulacae* (DC.) Kuntze resembles in general outlines that of *A. Bliti* (**4**), but differs from *A. candida* in several respects. The process of differentiation in the oogone of *A. Bliti* involves the crowding of the nuclei, undergoing mitosis, first into an indefinitely outlined zone away from the immediate center, and then to a point outside a sharply formed boundary (**5**, *Figs. 2, 3*). As a consequence of the orientation of certain of the spindles at right angles to the boundary of the ooplasm, completion of the mitosis results in the reëntrance of many nuclei into the oosphere. A second mitosis, involving only the nuclei of the oosphere, ensues, all the daughter nuclei remaining within the

ooplasm and functioning as female nuclei. In this species, the receptive papilla seen in *A. candida* (**6**) is more highly developed (**5**, *Figs. 1, 5*) and forms later, sometimes during the second mitosis. Fertilization in *A. Portulacae* is characterized by the fusion of the numerous female nuclei individually with male nuclei resulting from two mitoses in the antheridium simultaneous with those in the oogonium. No division of the fusion nuclei takes place prior to overwintering.

Before the appearance of Stevens' paper (**5**), Berlese (**1**) had investigated the formation of sex organs in *A. Portulacae* and had found several divisions of a smaller number of nuclei in the oogonium, fewer nuclei in the antheridium, no receptive papilla, and at time of fertilization a uninucleate condition of both antheridial tube and oosphere. In fact, these results differed so widely that Stevens in his paper suggests the possibility that they were observing different organisms.

The present observations seem in accord with those of Stevens (**5**), and figures 3 and 4 of this paper are easily identifiable with figures 2 and 7, respectively, of his report. Indeed, many of the stages described and figured by Stevens were observed, and it is intended to take no significant exception to the general sequence of events as reported.

Stevens reports, and figures (**5**, *Figs. 2, 3*), a definite nuclear membrane around each spindle of the first mitosis in the oogonium, and the lack of any such membrane around those of the second. Both of the mitoses within the antheridium have, according to him, spindles surrounded by a nuclear membrane similar to those of the first mitosis in the oogonium. No such nuclear membrane appears about the mitotic figures of the first division in the oogonia (FIG. 3) of the material here examined, but rather there is a close resemblance between such figures and those of the second division (FIG. 4). Nuclei at metaphase stages of the first mitosis in the antheridium (FIG. 2), on the other hand, clearly show a surrounding membrane. On the basis of this, the possibility exists that both oogonial mitoses have spindles which develop after the disappearance of the membrane, but that the membrane persists about the developing spindles of both antheridial mitoses as already described. No trace was seen of the prominent centrosomes noted



FIGS. 1–8.

by Stevens (**4**) in *A. Bliti.* Further, no structure undeniably a nucleolus was found, though it is not impossible that it was overlooked.

A brief description of the formation of conidia was included in the first description of the genus (as *Cystopus*) by Léveillé in 1847, and further described for *A. candida* by Berkeley in 1848, and for *A. Portulacae* by L. R. Tulasne in 1854. In the present material the formation of the conidia, with one important exception, agrees with the generally accepted story for the genus (**3**), showing the basipetally developing chains of spores, the coenocytic thick-walled conidiophores, and the gelatinous disjunctors. In addition, definite mitotic figures occur in the conidia, characteristically showing in the second, third, and fourth spores from the base of the chain (FIG. 6). Seldom if ever are all of the nuclei of the multinucleate conidia involved, although the number of dividing nuclei may range from a single one to as many as five or six. By the time a given conidium has become the fifth or sixth from the base, all nuclei are in a resting condition (FIG. 8).

Mitotic figures in maturing conidia closely resemble those in the oogonia, and neither nuclear membrane nor centrosome-like structures are recognizable. The spindle itself is at times somewhat curved, and during anaphase stages (FIG. 7) the fairly uniform spherical chromosomes move at varying speeds to the poles. As the age of a conidium increases, the cytoplasm becomes more finely vacuolate and uniform in structure.

Stevens (**4**, **5**) describes a resting nucleus as showing a prominent nucleolus and a faint "linin" network, with no chromosome-like bodies evident until the prophase stages of an incipient mitosis. In the present material there is a strong suggestion (FIG. 5) of the presence of relatively large chromatin aggregations throughout the resting stage. The nuclei of the vegetative hyphae (FIG. 5), of the young oogonia (FIG. 1), of the antheridia just prior to the first mitosis (FIG. 3), of the periplasm at the time of the second oogonial mitosis (FIG. 4), of the conidiophores (FIG. 6), and of the mature conidia (FIG. 8), as well as those accompanying the dividing nuclei of the young conidia, are similar in structure. These nuclei show several prominent, irregularly arranged, darkly staining bodies with few if any interconnecting strands, enclosed

within a nuclear membrane. These dark granules of the resting nuclei differ little in size from the chromosomes of the mitotic complex, and the number in each case is approximately eight, although the count is rendered somewhat uncertain by the minuteness of the nuclear structures. This evidence strongly suggests that they are prochromosomes.

The material used in this work was collected on *Portulaca oleracea* at Madison, Wisconsin, and was fixed in Carnoy's solution. All of the figures were drawn from slides stained by the iodine-gentian violet-picric acid technique, with the exception of figure 2, which was taken from a Heidenhain's haematoxylin preparation.

The writer wishes at this point to express his appreciation to Dr. E. M. Gilbert of the Botany Department for advice and criticism, and particularly to Dr. D. C. Cooper of the Genetics Department for the excellent slides on which the observations were made.

SUMMARY

1. The mitotic spindles of both first and second divisions in the developing oogonia of *A. Portulacae* appear to form after the disappearance of the nuclear membrane.

2. The spindles of the first antheridial mitosis are surrounded by the nuclear membrane at least as late as the metaphase stages. Spindles of the second mitosis were not observed.

3. In neither oogonia nor antheridia were centrosomes or nucleoli recognized.

4. Division figures closely resembling those in the oogonia appear in the maturing conidia, usually in the second, third, or fourth spore from the base of the chain. Not all the nuclei in a given spore undergo division, and older conidia show only resting nuclei.

5. Resting nuclei, wherever found, show dark granules which resemble in size and number (approximately eight) the chromosomes of the mitotic figures, and which are in all probability prochromosomes.

DEPARTMENT OF BOTANY,
UNIVERSITY OF WISCONSIN,
MADISON

LITERATURE CITED

Further references to early work on *Albugo* may be found in the citations appended to the following papers.

1. **Berlese, A. N.** Über die Befruchtung und Entwicklung der Oosphäre bei den Peronosporeen. Jahrb. Wiss. Bot. **31:** 159–196. 1898.
2. **Davis, B. M.** The fertilization of *Albugo candida*. Bot. Gaz. **29:** 297–310. 1900.
3. **Gaümann, E. & Dodge, C. W.** Comparative morphology of fungi. McGraw-Hill Book Co. New York, N. Y. 1928.
4. **Stevens, F. L.** The compound oosphere of *Albugo Bliti*. Bot. Gaz. **28:** 149–176, 225–245. 1899.
5. ——. Gametogenesis and fertilization in *Albugo*. Bot. Gaz. **32:** 77–98, 157–169, 238–261. 1901.
6. **Wager, H.** On the structure and reproduction of *Cystopus candidus* Lév. Ann. Bot. **10:** 295–342. 1896.

EXPLANATION OF FIGURES

Fig. 1, young oogonium, showing nuclei in resting condition (× 1115); 2, antheridium, in first mitotic division, showing intranuclear spindles (× 1675); 3, oogonium in early stages of zonation, showing numerous nuclei in metaphase of first mitosis, devoid of nuclear membrane or centrosomes (× 1115); 4, oogonium, fully differentiated into ooplasm and periplasm, with nuclei of ooplasm in metaphase of second mitosis and periplasmic nuclei in resting condition (× 1115); 5, portion of vegetative hypha (× 1115); 6, conidiophore and four basal conidia, showing nuclear divisions in the conidia and resting nuclei in the conidiophore (× 1675); 7, conidium showing divisions in anaphase stages, and chromosomes moving at varying speeds to poles (× 1675); 8, mature conidium with all nuclei again in a resting condition (× 1115).

STUDIES IN THE GENUS TYPHULA[1]

RUTH E. REMSBERG

(WITH 58 FIGURES)

The literature on the genus *Typhula* records at least eighty species. A few are frequently collected and are well described; many more are rarely collected and consequently only meager and unsatisfactory descriptions are available. It is evident that all recorded names do not represent distinct species. The student in mycology soon becomes bewildered with the current taxonomic situation in this genus, and is usually discouraged in his study of the group. It was with this situation in mind that this investigation was undertaken, and a study of these fungi has brought to light many interesting facts.

HISTORICAL ACCOUNT OF THE GENUS

Persoon (**25**) first recognized *Typhula* as a distinct group of fungi and made it a sub-division of *Clavaria,* using the subcapitate character of the clavula as a basis of separation from the other species of *Clavaria.* Fries elevated this sub-division to generic rank (**10**), retaining the name *Typhula,* and stating that the group composes a natural genus by virtue of cylindrical, fertile clavulae and distinct, filiform stipes. He lists four species: *T. erythropus, T. gyrans,* and *T. phacorrhiza* as having sclerotia present, and *T. Todei* with the sclerotium absent. The genus *Typhula* was retained by Fries in his Systema Mycologicum under the sub-order

[1] Also presented to the faculty of the Graduate School of Cornell University, June 1938, as a major thesis in partial fulfillment of the requirements for the degree of doctor of philosophy.

The writer wishes to express her sincere appreciation to Prof. H. H. Whetzel, under whom this investigation has been made, whose advice, suggestions, and criticisms during the study and in the preparation of this manuscript have been extremely valuable. Special acknowledgment is also due Dr. F. J. Seaver, N. Y. Botanical Garden, and Miss Anna Jenkins, Bureau of Plant Industry, for their assistance in making available many descriptions of species of fungi.

Clavati of the Hymenomycetes. He again separates it from the other genera by its slender, fertile clavula and distinct, filiform, sterile stipe. Eight species are listed: *T. gyrans, T. phacorrhiza, T. erythropus, T. villosa,* and *T. ramentacea* with sclerotia present, and *T. Todei, T. tenuis,* and *T. filiformis* in which the sclerotia are said to be absent. The characteristic upon which he divides the genus into two groups is the presence or presumed absence of sclerotia. Persoon (**26**), however, does not recognize the generic rank which Fries gave *Typhula* in his Observationes Mycologicae and in his Systema Mycologicum. The genus was still maintained by Fries in his Epicrisis Systematis Mycologici, and it has retained this rank throughout mycological literature to the present time.

Although the basidiomycetous nature of *Typhula* was not determined until after the middle of the nineteenth century, Fries stated that the spores in the closely related genus *Pistillaria* are emergent (**11**). Previous to that time, and for many years afterward, the spores were apparently not observed, or else the fruiting hymenium of these fungi was mistaken for an ascigerous layer. Berkeley (**3**) called attention to the fact that members of the Clavariei belong to the group of fungi in which the spores are borne exogenously on filiform apicules arising from an enlarged cell. Fuckel (**14**) was apparently the first to place the genus *Typhula* under the Basidiomycetes.

In Fries' last large taxonomic work on the group, Hymenomycetes Europaei, there are listed 23 species. Twelve have sclerotia and are brought together under the sub-division *Phacorrhiza.* Under *Leptorrhiza* he places those species which are said to be without sclerotia. These two divisions *Phacorrhiza* and *Leptorrhiza* are retained in almost all subsequent taxonomic treatments.

Much of the confusion in the taxonomy of these fungi arises from the attempt to separate species of *Typhula* from the closely related forms usually referred to *Pistillaria.* The genus *Pistillaria* was established by Fries (**11**) to include those fungi with slender fruit-bodies resembling those of the Typhulae, but in which a distinct stipe is lacking and with the hymenium covering the entire surface. Fries felt that this separation is unsatisfactory, and it has been found since that there are many overlapping forms in the two genera.

The genus *Pistillaria* gradually came to cover those forms which have, for the most part, two-spored basidia and no distinct stipe. Winter (**38**) and Schroeter (**32**) both follow this line of separation. Winter notes that in both genera, as at present constituted, are to be found forms with or without sclerotia, and that it is probable that sclerotia have not yet been found for some species of *Typhula*. This same separation of the species into two genera is given by Hennings (**16**) and Killerman (**19**); the two-spored forms without sclerotia being placed in *Pistillaria* and the four-spored forms with sclerotia in *Typhula*.

In the more recent taxonomic treatments by Saccardo (**30**) and Bourdot & Galzin (**5**), *Pistillaria* is treated to include forms with one to four spores, and *Typhula* forms with two to four spores. In both these works keys are given to a large number of species, based chiefly on sporophore characteristics.

Coker (**8**) does not use either the number of spores on the basidium or the presence or absence of sclerotia to separate *Typhula* from *Pistillaria*. He uses the character of the stipe as the chief basis for referring species to the respective genera. Those with short stout stipes he places in the genus *Pistillaria;* those with distinct, long filiform stipes in the genus *Typhula*. Coker also points out that there is some confusion as to the generic identity of certain small species which on account of the absence of sclerotia he refers to *Clavaria*. Previous workers distinguished the two groups on the basis of the slender filiform cartilaginous consistency of *Typhula* species in contrast with the larger stouter, fleshy consistency of those of *Clavaria*. However, Coker indicates that some species of *Clavaria* are to be excluded from *Typhula* solely by virtue of their size and indistinct stipe. He apparently attributes little significance to the presence or absence of sclerotia.

From a review of the taxonomic literature, it is evident that no entirely satisfactory basis for separating *Typhula* from related genera, and especially from *Pistillaria* has been proposed. The cartilaginous consistency and small size of the sporophores, with the fertile hymenium limited to a clavula usually serve to distinguish them from *Clavaria*. However, under the present systems, there are some border line species which are difficult to place. The use of the number of spores on a basidium as a character in dis-

tinguishing species of *Typhula* and *Pistillaria* is untenable, since two-spored and four-spored basidia are to be found in typical species of both genera. The presence of sclerotia appears to the writer to be the most reliable single character for distinguishing species of *Typhula* from those of *Pistillaria* or *Clavaria*. The presence of a swollen hymenial portion, the clavula, distinct from the filiform stipe, also appears to be a characteristic of *Typhula* species.

METHODS AND RESULTS OF INVESTIGATIONS

A great deal of interest has been aroused during the past fifteen years concerning the injury caused by pathogenic species of *Typhula* in cereals and grasses. Serious injury to winter wheat was first reported in the United States in 1922 from Fremont and Teton Counties in Idaho (**17**). At that time the disease was attributed to *Sclerotium rhizodes*, but examination of material collected then has shown it to be a species of *Typhula*. It has occurred nearly every year since in various northern and high altitude wheat sections of that state. It has also been reported from Washington (**15**) and Montana (**40, 39**), as well as from Japan (**4, 20, 18, 33**) and Germany (**9, 21, 23, 36**). The disease is most commonly found in localities where the snow remains on the fields late in the spring. Accounts of investigations of the disease in the Western United States is given by Remsberg and Hungerford (**29**) and by Young (**41**). The same species of *Typhula* has been collected on lawn and turf grasses in Idaho, New York, and Pennsylvania. Many other species are collected frequently on overwintered herbaceous stems and leaves, where they have probably developed saprogenically.

Sclerotia are as a rule to be found in great abundance, but very rarely have the sporophores been observed. Since all previous taxonomic treatments are based chiefly on sporophore characters, it was found very difficult to identify our collections of sclerotia with the described species. These fungi are readily grown on agar where large numbers of sclerotia are easily produced, but seldom had fertile sporophores been obtained in culture. The problem then became one of determining under what conditions these fungi fruit and to duplicate these conditions experimentally.

It soon became apparent from field observations and from studies of the fungi in culture that many of the species, especially the pathogenic ones had unusually low optimum temperatures. In culture these optimum temperatures range from 6–12° C., with abundant growth as low as 0–3° C. In the field the pathogenic species are found growing just under the edge and beyond the receding snow. The saprogenic species are also usually found in greatest abundance just after the snow has melted. When the fruiting bodies of *Typhula* have been collected, it is usually during the rainy cold weather of autumn, or in the case of some species, in the early spring. Hence, it appeared that optimum conditions for fruiting are cold weather, abundant moisture, and high humidity.

Numerous attempts were made to produce sporophores in culture on agar by varying the nutrients, temperature, and light in the laboratory, but in all cases sterile sporophores only were produced. Other experiments were performed in which the sclerotia, produced either in culture or collected in nature, when placed on sand at low temperatures always resulted in the production of sterile sporophores. In order to obtain fluctuating natural temperatures, sclerotia were placed out-of-doors in glass containers, but always failed to produce fruit-bodies. Since in all these experiments the sclerotia were either under glass or in total darkness, it became evident that another condition necessary for fructification might be direct daylight. Tasugi performed similar experiments in Japan with the same results, but found that sclerotia gave normal fruiting when exposed directly to natural daylight (**33**) or under vitaglass (**34**).

With these factors in mind, the following experiment was set up. A wooden cigar box supported by a block of wood at each corner was placed in a shallow aluminum pan. First, a layer of peat or sphagnum moss was placed in the box and then a layer of sand was put in on top so that the box was approximately half full. Water was kept in the bottom of the pan and cheese cloth was placed over the box in such a manner that it hung down over the sides and into the water in the pan. In this way the cheese cloth acted as a wick to draw the water up over the box, thus keeping the sand moist and maintaining a high humidity.

An abundant supply of sclerotia was obtained by growing the fungi in culture on potato dextrose agar or on sterilized wheat kernels. These sclerotia were placed on the surface of the sand, and the pans and boxes were put out-of-doors in diffused daylight during the months of February, March, and April, 1936 and 1937. During the time when the outdoor temperature remained near 0° C. for most of the day and night, and cold rain and snow flurries prevailed, numerous sporophores developed. These appeared in two to four weeks after planting the sclerotia, depending on the species and the weather conditions. These experiments were repeated in the autumn during September, October, and November, with the same results during those years.

These experiences suggested that short rays of natural daylight, which are not transmitted through ordinary glass, play an important role in the stimulation of the fungi to fructification. An abundance of sporophores were then obtained under artificially controlled conditions which closely approximated the natural conditions under which they had previously appeared. The pans and boxes were placed in a refrigerator room in which the temperature was kept at 32–38° F. A source of ultra-violet light was provided by employing a General Electric Sunlamp, Model F, using an Edison S-1 sunlamp bulb. This was installed in such a manner that the boxes were 20–30 inches from the source of light. An exposure for a total of two hours daily was given. In 2–4 weeks, typical sporophores developed. It was thus possible to duplicate artificially the optimum natural conditions for fructification and to obtain sporophores at will during any time of the year.

In order to determine the character of the light waves which seemed to be influential in the stimulation of fructification, a series of filters was used in an experiment set up out-of-doors as described above. The filters were placed over the boxes under the cheese cloth. Where ordinary window glass was used, no sporophores were produced. It has been shown that common window glass does not transmit light of shorter wave length in the ultra-violet region of the spectrum than approximately 3250 Angstrom units.[2] However, when vitaglass,[3] which transmits light waves of 2650–

[2] Pamphlet: Glass color filters manufactured by Corning Glass Works, Corning, New York, 1935.

[3] Supplied by the Vita Glass Corporation, New York City.

6690 Angstrom units, was used as a filter, normal fruiting of the fungi took place. The range of light which stimulates fructification is thus indicated to lie between 2650 and 3250 Angstrom units. Fertile sporophores are produced under the Corning glass filter No. 970 Corex D.[4] This glass transmits at least 60 per cent in the region of 3020 Angstrom units, with a sharp decrease to 10 per cent at 2700 Angstrom units. It is indicated by these experiments with the filters that the region which apparently stimulates fructification of *Typhula* lies approximately in the region between 2700 and 3250 Angstrom units.

CULTURAL STUDIES

These fungi are easily obtained in culture on potato dextrose agar from sclerotia, diseased tissue, or from shot basidiospores. The sclerotia or pieces of diseased tissues were surface disinfested with calcium hypochlorite[5] and planted directly on the agar. Sporophores were fastened inside on the lid of a petri dish and the basidiospores were allowed to shoot down onto the surface of the agar.

The temperature range for growth was determined for each species studied. All fourteen species made fairly good growth at 0° C. Growth at temperatures below 0° was not tested. The maximum for all the species varied between 18° and 27° C. The optimum for three of the species was relatively low, being in the neighborhood of 6–12° C. The optimum for the other species lay between 12° and 21° C. The minimum, maximum, and optimum temperatures for growth for each species will be found in the notes under taxonomic studies.

It will be found that the range and optimum temperatures for the pathogenic species run consistently low as compared with the saprogenic species. This is in direct correlation with the fact that the pathogenic activities of *T. Itoana, T. idahoensis,* and *T. umbrina* occur at low temperatures in the field and garden.

Mycelial growth on potato dextrose agar in most species is typi-

[4] Supplied by the Corning Glass Works, Corning, New York.

[5] A fresh solution of 10 g. calcium hypochlorite in 140 cc. water was used according to the formula given by Wilson (37). The material to be disinfested was allowed to remain in the solution 5–15 min.

cally of a radiating fan-shape, and may or may not be accompanied by fluffy aerial mycelium. In other species it may consist of an extremely suppressed or submerged mycelial growth of hydrotic aspect. In the majority of the species a brown stromatic crust is formed at or near the maximum temperature for growth (FIG. 5). This crust is of the same nature as the sclerotial rind, the hyphae becoming gnarled, enlarged, thickened, and agglutinated into a more or less compact hardened layer. In the case of *T. gyrans* and *T. phacorrhiza* the mycelial growth in the agar becomes a tough cartilaginous layer difficult to cut or break.

Sclerotia appear in culture in 5 days to 2 weeks and are formed singly (FIG. 2), in coalesced masses (FIG. 3) or in concentric rings (FIG. 4). At extreme low temperatures there is a tendency for the sclerotia to grow in piles or masses, while at extreme high temperatures they are scattered. In all cases there is an abundant extrusion of moisture from the sclerotia during formation. When drops of this liquid are dried on a glass slide, a crystalline residue or deposit is formed.

In many species there is a tendency toward formation of a-typical, sterile sporophores in culture (FIG. 6). These may develop from sclerotia, stromatic cursts, or from mycelial mats on the surface of the agar. In some instances these may approach the appearance of typical sporophores, but usually remain sterile. However, *T. sphaeroidea* has been observed to form fertile sporophores from mycelium on agar in culture on rare occasions at 9–21° C. These sporophores resemble very closely those produced under natural conditions.

GENETIC MORPHOLOGY

A critical study of the morphology of the species at our disposal was made in the hope of finding characteristics which would serve in the identification of species and to disclose, if possible, a more satisfactory basis for defining the generic concept for this group of forms.

A study of the development of the sclerotium agrees with the account given by DeBary (**1**). A tuft of much branched hyphae arises from the mycelium in the substratum, and becomes a ball of enlarged hyphal cells. It increases in size by repeated branching

of the hyphae as they become intertwined. The peripheral cells become fused early, and consequently are much distorted as the sclerotium increases in size. These peripheral cells become the thickened gelatinized rind, and the intertwining hyphae within become the medulla, which is rich in stored food material. When these balls of hyphae develop in isolated positions, the sclerotia are formed singly; when the sclerotial initials arise close together, they often fuse with each other so that when the rind develops, it will enclose several balls, thus giving rise to coalesced sclerotia.

Very little mention is made of sclerotial morphology in any of the taxonomic treatments, other than meager descriptions of the general shape, size, and color. However, DeBary (1) discusses two types of medulla construction found in species of *Typhula*. He observed in *T. variabilis* that the medulla is made up of enlarged intertwined hyphae with here and there inter-hyphal spaces, while in *T. phacorrhiza* the medulla is of cartilaginous consistency in which the gelatinous cell walls have completely fused so that the lumina of the cells appear to be embedded in a continuous hyaline matrix. Both these types have been found to exist in the species studied. The medulla first described may be said to be of a **prosoplectenchymatous**[6] type (FIG. 38). The second is to be designated as **paraplectenchymatous** (FIG. 46). In some species, the contacting walls may still be visible, but with no inter-hyphal spaces, appearing to form a solid parenchyma. This third kind of medullary structure may be designated the **pseudoparenchymatous** type (FIG. 40). Young sclerotia in section may show transition stages in the formation of either of the three types of medulla. In the center will be found small thin-walled, smooth hyphae, others with walls becoming gelatinized and thickened with the lumina appearing crooked. The hyphae become more compact toward the periphery of the sclerotium, and in the case of the paraplectenchymatous medulla, different stages of hyphal fusion will be seen with complete fusion adjacent to the rind. Thus it is seen that in all cases the hyphae of the medulla have thickened gelatinous walls and are not thin-walled as deBary seems to imply (1: 35).

The dark colored rind of the sclerotium is either a homogeneous

[6] Snell, W. H. Three thousand mycological terms, p. 1–151. 1936.

gelatinous deposit on the outer walls of peripheral hyphal cells (FIG. 46), or is made up of layers of hyphae wound about the medulla (FIG. 45). The walls of these hyphae become thickened and darkened. The hyphae are agglutinated but often sluff away from the surface as the sclerotium enlarges, until but a layer or two is left. The rind cells of all species are enlarged and distorted, so that in surface view they appear in an irregular or angular pattern (FIGS. 32, 33). In some species these cells become tuberculate, often forming miniature rosettes scattered over the surface of the sclerotium (FIG. 37).

The sporophores usually arise directly from sclerotia both in nature and under artificial conditions. They have, however, been observed to arise from the stromatic crusts formed on culture media at high temperatures, and occasionally also direct from creeping rhizomorphic strands or even from mycelial mats. The stolon-like rhizomorphic strands, although originating from the sclerotia placed on sand, often grow along the surface or through debris for some distance before giving rise to the sporophores. Since in collecting the sporophores they are easily detached from the sclerotia and as they do not always arise directly from the sclerotia, it is easy to understand why many collections have been made of the fruit-bodies in which sclerotia apparently have been absent. For this reason, culturing of species suspected of belonging to *Typhula* is of great value in determining whether or not sclerotia are actually produced.

The sporophores are typically small, slender, filiform, clavate bodies of cartilaginous consistency which become hairlike and flexuous when dry, and which will revive to their original size and texture on soaking in water. The sporophore is divided into a distinct, filiform, sterile stipe and a cylindrical clavula bearing the fertile hymenium; it may be completely white or variously colored, according to the species. The sporophore is made up of upright agglutinated, parallel strands of hyphae which give rise to the basidia at right angles in the clavula. These strands of hyphae may be completely fused to give a pseudoparenchymatous aspect to the subhymenium (FIG. 48), or they may be loosely interwoven (FIG. 52).

The basidiospores are produced on slender, hair-like, attenuated

sterigmata at the apex of the basidium. The number of spores to the basidium varies with the different species from two to four, and even six to eight in one species (FIG. 1, *b–e*). Under some conditions, especially when fruiting sporophores are kept in total darkness for 24 hours, basidia are found producing but one basidiospore, or maturing one at the expense of the others (FIG. 1, *a*). Since this is of unusual occurrence and is found only under abnormal conditions, it is not considered of any taxonomic importance. The spores of all species studied are of the same general shape, ovate or elongate, inaequilateral, flattened or incurved along one side above the apiculus (FIGS. 53–57) are shot away at maturity and germinate by one or more germ tubes.

It was observed from time to time during these studies that several species of *Typhula* produced minute micro-conidial-like bodies in abundance in old cultures on potato dextrose agar. These bodies are rod-shaped, cylindrical, approximately 2 μ wide and varying from 4 to 6 μ in length. They are borne on the old mycelium from short lateral branches (FIG. 58). Brefeld illustrates similar bodies for *T. variabilis* (**6**: 219, *pl. 8, f. 2*). The function of these micro-conidia has not been demonstrated.

TAXONOMIC STUDIES

The following suggestions for placing the genus *Typhula* more satisfactorily in the taxonomic system are presented as a result of these studies. It seems desirable to place most emphasis on the sclerotia, since they are more frequently and abundantly collected, rather than on the sporophores which are, when found, not strikingly distinct from the sporophores of certain species in related genera.

It is suggested that the genus *Typhula* be used to include those species with small, filiform, clavate sporophores which normally arise from sclerotia, and the genus *Pistillaria* to include similar forms in which sclerotia are wanting. It will often be necessary to grow these fungi in culture to be sure that sclerotia are present or absent in the life cycle. However, since this is a very easy process and one which is of value in determining the morphology of sclerotia for the separation of different species, it is entirely desirable.

If further studies disclose a strict correlation of the slender stipe

and distinct clavula with the presence of sclerotia in *Typhula* and the indistinct clavula and absence of sclerotia in *Pistillaria*, the distinction between the two genera will be strengthened considerably. If this correlation cannot be established, the separation of the two

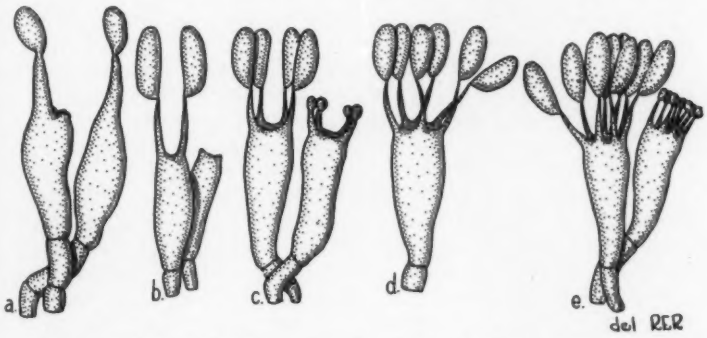


FIG. 1. Basidia and basidiospores of species of *Typhula*. Approx. × 450. *a*, basidia of fruiting sporophores which had been kept in the dark 24 hours, producing but one basidiospore; *b*, two-spored basidium; *c*, four-spored basidium; *d*, six-spored basidium; *e*, eight-spored basidium.

genera on the basis of the presence or absence of sclerotia alone, still affords a satisfactory and reliable distinction between them.

In this investigation it was possible by culturing the fungi to obtain an abundance of material of both sclerotia and sporophores, so that repeated studies of the species could be made. In this way it was possible to observe variations within a given species which hitherto had lead early workers to erect different species based upon meager or isolated collections. Thus we have been able to reduce to synonymy names of several species found in the literature and disclose many as yet undescribed species.

The characters which have been used here in the separation of species within the genus are chiefly those of sclerotial morphology, although sporophore characters have been drawn upon as far as they are available. Sclerotia produced in culture are found to agree in morphology and color with those obtained in the original collections. Colors are given according to Ridgway.[7]

[7] Ridgway, Robert. Color standards and color nomenclature, p. I–III + 1–43. 1912.

TYPHULA Fries, Obs. Myc. 296. 1818. Syst. Myc. 1: 494. 1821

Sclerotia arising from branched, septate, mycelium with clamp connections and frequent anastomoses; white or pale and translucent when young, becoming tawny, reddish-brown, dark-brown or nearly black as the rind develops with maturity; superficial, erumpent or immersed in substrate, adherent or falling away easily, attachment sometimes by minute stalk; single, clustered, or coalesced into masses; smooth, roughened, furrowed or tuberculate, shrunken with age, collapsed after fructification; spherical, subglobose, flattened or concave below, rounded above, or pyriform and flattened laterally; rind colored, composed either of a tough, gelatinous layer deposited on the outer walls of enlarged, peripheral, hyphal cells, or of compactly intertwined hyphae wound about the medulla at the periphery; medulla white or light colored, often cartilaginous, made up of intertwining enlarged, septate, branched hyphae whose lumina become narrow and crooked, and whose walls become thickened, gelatinized and translucent, appearing prosoplectenchymatous, paraplectenchymatous, or pseudoparenchymatous, often containing embedded crystals; solid, with center often composed of loosely interwoven hyphae, or hollow in the case of large sclerotia or coalesced sclerotial masses.

Sporophores cartilaginous, one or more arising from the medulla of the sclerotium, from a stromatic crust, mycelial mat, or creeping stolons which originate from sclerotia; small, clavate, awl-shaped or filiform, erect, straight or curved, flexuous or prostrate, apex acute or obtuse, base filiform; simple or with branches arising at any point along the main axis; translucent when young, opaque when old or dry.

Clavula straight or curved, cylindrical, flattened or furrowed; composing the upper half or two-thirds of the sporophore; tip sometimes sterile; translucent when young, becoming opaque and pruinose with spores at maturity; often proliferating to form new clavulae; simple or branched with apex attenuate or blunt, and usually sharply distinguished from the stipe; smooth or often pubescent with age; hollow or solid, the subhymenial layer pseudoparenchymatous or loosely interwoven, with or without embedded crystals.

Stipe distinct in size or color from clavula especially at maturity; erect, flexuous, prostrate or creeping, cylindrical, filiform; translucent when young, shiny or dull when dry or old; smooth or pubescent with basal hairs often clasping the sclerotium; solid or hollow, made up of compactly agglutinated, parallel hyphae with or without incrustations.

Basidia 2- 4- 6- or 8-spored, clavate, slender and elongate or

broad and short, hyaline; the a-paraphasate hymenium often obscured by incrustations; adherent or breaking away from subhymenial layer; with or without clamp connections at base.

Sterigmata hyaline, straight and awl-shaped, curved or hooked, tapering to a hair-like tip; about 8 μ long and 2 μ wide at the base.

Basidiospores hyaline, smooth, inaequilateral, usually flattened or slightly incurved on one side above an apiculus.

Conidio known.[8]

Micro-conidia sometimes present in culture, hyaline, smooth, cylindrical, approximately 2 μ wide and 4–6 μ in length, borne on short lateral branches from the main hypha, non-germinating (?), function undetermined.

TYPE SPECIES

The species *Typhula phacorrhiza* Reichard ex Fries has been chosen as the neo-type species of the genus *Typhula*. The first name applied to the perfect stage of any species of fungus later to be placed in *Typhula* was *phacorrhiza*, when Reichard (**28**) used it for a species which he referred to *Clavaria*. The species *Clavaria phacorrhiza* was acknowledged by Persoon in his Commentatio de Fungus Clavaeformibus and also in his Synopsis Methodica Fungorum. It is the oldest of the three species of *Clavaria* elevated by Fries (**10**) to generic rank under the name *Typhula*, and was one of the eight species in this genus described in Fries' Systema Mycologicum.

This species has been most frequently collected, is very abundant, and there are more complete descriptions and illustrations in the literature for it than for any other species of the genus. For these reasons it has been chosen as the species typical of the genus.

KEY TO SPECIES[9]

I. Sclerotia with medulla paraplectenchymatous or pseudoparenchymatous, center often somewhat prosoplectenchymatous; rind either a homogeneous gelatinous layer or composed of intertwining hyphae.

[8] Condia have been frequently observed by the writer both in culture and in nature for a single, as yet unidentified species of *Typhula*. They are produced in great abundance on sporodochia which develop from massed sclerotia or stromata, are large, cylindrical, borne on long conidiophores and germinate by one or more germ tubes.

[9] The key and following descriptions of species are based primarily on characters exhibited by these fungi grown under artificial conditons, corresponding in general with the characters under natural conditions in so far as we have been able to observe them.

A. Medulla paraplectenchymatous.

1. Rind a homogeneous gelatinous layer; sporophores colored.

a. Sclerotia superficial, adherent by minute reddish brown stalk, pyriform or flattened laterally on two sides, 1–3 × 4–5 mm., cinnamon-brown to Mars-brown;[10] sporophore filiform, tawny to russet, 20–100 mm. tall. 1. *T. phacorrhiza.*

b. Sclerotia immersed-erumpent, spherical to subglobose, 0.5–4.0 mm., tawny to hazel-brown; sporophore clavate, rose colored, 8–25 mm. tall. .....2. *T. Itoana.*

2. Rind composed of intertwining hyphae; sporophores white, often with reddish-brown base.

a. Rind[11] cells paraplectenchymatous, extending irregularly into the medulla; medulla paraplectenchymatous throughout or with center of loosely interwoven hyphae bounded by dark cells resembling an internal rind, 0.5–1.0 mm., wood-brown to nearly black; sporophore broadly clavate, 1–3 mm. tall. .....3. *T. sphaeroidea.*

b. Rind cells prosoplectenchymatous, in a uniform layer about the medulla; medulla paraplectenchymatous throughout or prosoplectenchymatous in center with no internal rind, 0.5–3.0 mm., natal brown to clove brown; medulla paraplectenchymatous; sporophores 5–15 mm. tall. 4. *T. gyrans.*

B. Medulla pseudoparenchymatous.

1. Rind composed of intertwining hyphae; sporophores white with reddish brown base.

a. Sclerotia single or clustered, rarely coalesced 0.5–1.0 mm., auburn to chestnut-brown; medulla pseudoparenchymatous; sporophores 2–6 mm. tall. .....5. *T. Viburni.*

II. Sclerotia with medulla entirely or for the most part prosoplectenchymatous; rind a homogeneous gelatinous layer.

A. Medulla immediately adjacent to rind composed of greatly enlarged cells; center prosoplectenchymatous.

1. Sclerotia always single, never coalesced, van dyke-brown to chestnut-brown; sporophores avellaneous to wood-brown, 8–15 mm. tall. .....6. *T. umbrina.*

2. Sclerotia single or coalesced; sporophores white or colored.

a. Sclerotia large, 3–6 mm., chestnut-brown to nearly black; sporophores olive-buff to smoke-grey, 30–50 mm. tall. 7. *T. variabilis.*

b. Sclerotia small, 0.5–3.0 mm.; sporophores entirely white.

1′. Sclerotia 0.5–0.8 mm., Verona-brown; sporophores 4–12 mm. tall. .....8. *T. virgata.*

2′. Sclerotia 2–3 mm., bister to nearly black; sporophores 6–22 mm. tall. .....9. *T. pertenuis.*

[10] Ridgway, R. Color standards and color nomenclature, p. I–III + 1–43. 1912.

[11] Sclerotia rarely developing on potato dextrose agar. Sporophore here usually arising directly from the mycelium.

B. Medulla prosoplectenchymatous throughout; cells not prominently enlarged adjacent to rind.

1. Sclerotia always single, never coalesced.

a. Sclerotia 0.5–3.5 mm., van dyke-brown; fertile sporophores clavate, white, simple (sterile, filiform, branched sporophores often occur along with the normal clavate ones), 18–40 mm. tall. .....10. *T. intermedia.*

b. Sclerotia 0.5–2.0 mm., chestnut-brown to bone-brown; sporophores very rarely branched, fawn to wood-brown, clavate, 5–10 mm. tall. .....11. *T. idahoensis.*

2. Sclerotia single or coalesced.

a. Sclerotia minute, 0.5–1.5 mm., clay to tawny-olive or clove-brown; sporophores entirely white, simple or many times branched, 4–15 mm. tall. .....12. *T. Athyrii.*

b. Sclerotia small, 1.5–3.0 mm.; sporophores white or colored, simple.

1'. Sclerotia 1.5–3.0 mm., bone-brown; sporophores white to pale olive-buff, clavula sub-globose or flattened, 6–18 mm. tall. .....13. *T. latissima.*

2'. Sclerotia 2.0–2.8 mm.; sporophores light drab to drab, clavula broadened and awl-shape, 9–18 mm. tall. 14. *T. subulata.*

1. TYPHULA PHACORRHIZA Reichard ex Fries, Syst. Myc. **1**: 495. 1821.

Clavaria phacorrhiza Reichard, Schrift. Berl. Ges. Nat. Fr. **1**: 315. *pl. 1, f. 4, 5.* 1780.

Clavaria cylindrica Tode, Schrift. Berl. Ges. Nat. Fr. **4**: 166. 1783.

Sclerotium complanatum Tode, Fungi Meckl. **1**: 5–6. *pl. 1, f. 9a–d.* 1790.

Clavaria hirta Vahl, Pl. Dan. **21**: 8. *pl. 1257.* 1799.

Clavaria triuncialis Pers. Syn. Fung. **1**: 600. 1801.

Sclerotium scutellatum Alb. & Schw. Consp. Fung. 289. 1805.

Clavaria triuncialis var. *juncea* Alb. & Schw. Consp. Fung. 289. 1805.

Clavaria juncea Fries, Obs. Myc. **2**: 291. 1818.

Clavaria juncea var. *vivipara* Fries, Syst. Myc. **1**: 479. 1821.

Clavaria virgultorum Pers. Myc. Eur. **1**: 186. 1822.

Phacorrhiza filiformis Grev. Fl. Edin. 415. 1824.

Typhula erythropus Schnizlein,[12] in Sturm, Deuts. Fl. Pilze **31**: 23. *pl. 12.* 1851.

[12] This combination and citation is referred to by Winter (**38**).

Typhula juncea (Fries) Karsten, Hattsv. **2**: 181. 1882.
Typhula complanata (Tode) DeBary, Vergl. Morph. Pilze 44. 1884.
Clavaria scutellata DeBary, Vergl. Morph. Pilze 44. 1884.
Typhula subphacorrhiza Britz. Hymen. Südb. **8**: 15. *f. 77–78.* 1891.

ILLUSTRATIONS (in addition to the above): DeBary, Vergl. Morph. Pilze, *f. 15a–b,* 1884; Berk. Intell. Obs. **1**: *289–294. f. 1–2.* 1862; Bischoff, Krypt. *f. 3397.* 1860; Boud. Ic. Myc. **1**: *pl. 176.* 1904; Britz. Hymen. Südb. **8**: *f. 77–78.* 1891; Britz. Bot. Centr. **26**: *pl. 746.* 1910; Bull. Hist. Champ. Fr. **1**: *pl. 462, f. 2.* 1791; Coker, Clavarias, *pl. 84, f. 4.* 1923; Corda, Ic. Fung. **3**: *pl. 3, f. 56.* 1839; Grev. Scott. Crypt. Fl. **3**: *pl. 144, f. 1.* 1825; Harper, Mycologia **10**: 53–57. *pl. 5.* 1918; Henn. in E. & P. Nat. Pfl. **1**: *f. 71L.* 1900: Herter, Krypt.-Fl. Mark Brandenburg **6**: 147, *f. 2a–b.* 1910; Loudon, Encyclop. *f. 16192,* 1855; Micheli, Nov. Pl. Gen. *pl. 87, f. 7.* 1729; Nees, Syst. Pilze Schw. *pl. 14, f. 139–140.* 1816; Pat. Tab. Anal. Fung. **3**: *pl. 469.* 1883; Sicard, Hist. Nat. Champ. *f. 326.* 1884; Smith, Syn. Br. Basid. *f. 110A.* 1908; Stevenson, Hymen. Brit. **2**: *f. 94.* 1886; Winter, in Rab. Krypt.-Fl. **1**: 293. 1884.

MATERIAL EXAMINED: C. U.,[13] Rab. Fungi Eu. *239 Typhula phacorrhiza* Fries; Krieger, Fungi Sax. *417* and *418 Typhula complanata* DeBary; Krieger, Fungi Sax. *1421 Typhula juncea* Alb. & Schw.

Sclerotia (FIG. 10) tawny to russet, later cinnamon-brown to Mars-brown, superficial on substrate, very adherent by minute dark-brown or reddish-brown stalks, single or massed into clusters, lobed and irregular in shape, smooth at first, becoming wrinkled or furrowed on drying or with age, very cartilaginous in consistency, pyriform with stalk at narrowed end, apex often broadened, rounded or lobed, characteristically flattened especially on drying or aging, when single, 1–3 by 2–4 by 3–5 mm. in size, when coalesced, the masses are 10–15 mm. in diameter; rind (FIG. 35) yellow to reddish-brown, made up of tough gelatinous layer on the outer walls of irregularly distorted and enlarged peripheral

[13] The abbreviation "C. U." is used in this paper to designate the Herbarium of the Department of Plant Pathology, Cornell University.

cells, medulla (FIG. 46) tough, cartilaginous, paraplectenchymatous, center often prosoplectenchymatous with hyphae loosely interwoven, usually solid, very large sclerotia and sclerotial masses often hollow; sporophores (FIGS. 11, 47) filiform, erect, flexuous, straight or curved, apex usually acute, tapering below into a very long filiform stipe, not always well differentiated into stipe and clavula except at maturity, simple or branched, one or more (usually one) arising from any point on the sclerotium, sometimes arising directly from the mycelium, pubescent at the base, 20–100 mm. or more in length, translucent and shining when young, tawny to russet when mature, darker at the apex, whitish and opaque when dry; clavula straight or curved, cylindrical, elongate-fusiform, apex acute or rounded, 10–15 mm. long, 0.5–1.0 mm. in diameter, tawny to russet, tip sterile, darker, cinnoman-brown to Mars-brown, whitish when mature due to powdery layer of spores, hollow, subhymenium of small pseudoparenchymatous cells, densely crowded with coarse, dark-brown crystals which frequently obscure the origin of the basidia (FIG. 48), tissue below subhymenium also pseudoparenchymatous but of larger and looser cells, interior finally made up of loosely interwoven septate hyphae, or more often hollow; stipe distinct in size from clavula only at maturity, erect, flexuous, increasing gradually into clavula, pubescent only at base, 15–20 mm. long, 0.3–0.5 mm. in diameter, tawny to russet, shining when old or dry, solid or hollow, hyphae incrusted with dark crystals in parallel rows along the length of the stipe; basidia (FIG. 49) broad, cylindrical with very short stalk, rounded at the apex, four-spored, 27–33 μ long, 9–11 μ in diameter; basidiospores (FIG. 53) ovoid to sub-fusiform, flattened on one side above a cylindrical apiculus, 3.89–7.78 $\times$ 9.73–13.62 μ, average 5.84 $\times$ 11.64 μ.

HAB.: On overwintered leaves, petioles, herbaceous stems, grass, etc. Sclerotia are found in the spring, the sporophores arising in the autumn from the sclerotia or from the mycelium.

HERBARIUM SPECIMENS: C. U. *25233, 26950,* N. Y., Mar.–Apr., on buckwheat straw; *27045, 27046, 27043,* N. Y., Feb.–May, on *Acer* sp., *Alnus incana* and other leaves; *27042,* N. Y., Mar., on corn fodder; *27044,* N. Y., May, on *Solidago* sp. stems; *27047,* N. Y., May, on lawn grass and overwintered leaves.

NOTES: The fungus grows in culture from 0–21° C., with an optimum temperature of 12–15° C. Mycelial growth is appressed, granular, often concentrically banded and fan-shaped, forming a

rough cartilaginous mat over the surface of the agar. Sclerotia, which appear in 7–12 days, are very adherent to the surface of the agar, are clustered or in concentric rings, typically pyriform and flattened laterally, white at first, later russet to cinnamon-brown. Long sterile, yellowish-brown sporophores develop abundantly in culture from either sclerotia or the mycelium.

2. TYPHULA ITOANA Imai, Trans. Sapporo Nat. Hist. Soc. 11: 39–44. 1929.

MATERIAL EXAMINED: C. U., Roum. Fungi Gall. *1400 Sclerotium fulvum* Fries, Karsten's Herbarium Helsingfors, Finland:[14] *Typhula graminum* Karsten (type material) on leaves of *Calamagrostis* sp. and *T. graminum* Karsten on *Polystichum spinulosum*.

Sclerotia (FIG. 17) tawny to hazel-brown, immersed-erumpent, frequently falling away from substrate, single or coalesced, smooth at first, rough when dry or old, spherical to subglobose, often somewhat flattened or concave below and convex above, 0.5–2.0 by 1.5–4.0 mm.; rind (FIG. 30) golden to reddish-brown, about 7.78 μ thick, tough, composed of a smooth gelatinous layer on the outer walls of enlarged peripheral cells; medulla (FIG. 42), paraplectenchymatous, center often prosoplectenchymatous with hyphae loosely interwoven, small sclerotia solid, large ones and coalesced masses often hollow; sporophores (FIG. 19) clavate, erect, straight or slightly curved, apex broad, round or slightly pointed, tapering into stipe, simple or branched, one or more (usually one) arising from each sclerotium, often slightly pubescent at the base, 8–25 mm. tall, clavula rose color, opaque, stipe white, translucent, becoming flesh color to bittersweet pink when dry; clavula straight, erect, smooth, cylindrical or somewhat broadened and flattened, tapering toward a round or slightly pointed apex, 10–15 mm. tall, 1–2 mm. broad, hydrangea pink to pale vinaceous-pink, made up of a hollow cylinder of agglutinated hyphae bearing the hymenium which is continuous over the apex, crystals present in the hymenium and subhymenium; stipe distinct in size and color from the clavula, erect, straight, pubescent at the base with hairs clasping the sclerotium, 5–10 mm. long, 0.5–1.0 mm. in diameter, white, solid, hyphae often slightly incrusted with fine crystals; basidia (FIG. 52) broadly clavate, 27.23–34.62 μ long, 5.06–7.78 μ wide; basidiospores (FIG. 56) ovoid, flattened on one side above a pointed apiculus, 4.28–7.78 $\times$ 11.29–14.78 μ, average 6.05 $\times$ 11.71 μ.

[14] Lent to us through the courtesy of Dr. Harald Lindberg, Helsingfors, Finland.

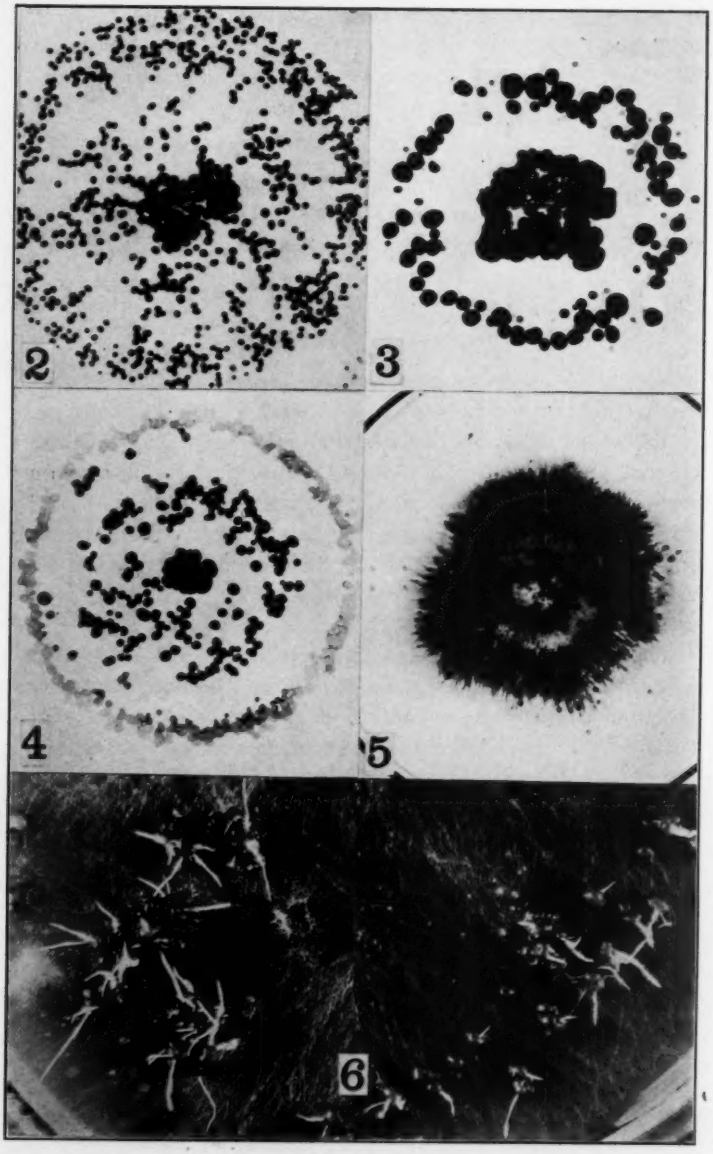
HAB.: Pathogenic on *Triticum, Hordeum, Phleum, Poa, Secale, Alopecurus,* and *Dactylis* sp. as well as saprogenic on herbaceous stems and leaves. Sclerotia are found in the spring after the snow melts, the sporophores arising from sclerotia in the autumn.

HERBARIUM SPECIMENS: C. U. *19192, 27211, 27212, 27213, 27214, 27215, 27216, 27217, 27218,* N. Y., Feb.–June, *27219,* Oct., *25211, 27100,* Ida., Mar., on turf and lawn grass; *25236,* N. Y., Mar., *27098,* Ida., Mar., on *Dactylis glomerata; 27099, 25154,* Ida., Mar., *27095,* Japan, May, on *Hordeum* sp.; *26156,* Ida., Mar., *25155,* Japan, May, on *Triticum* sp.; *27096,* Japan, May, on *Phleum* sp.; *27097,* Japan, Apr., on *Alopecurus fulvus.*

NOTES: The fungus grows in culture at 0–18° C. with an optimum temperature of 9–12° C. Mycelial growth is abundant, white, webby, radiating, concentrically banded, and fan-shape. Sclerotia, which appear in 5–10 days, are pinkish orange when young and tawny to hazel brown when mature, single or coalesced with a tendency to develop in concentric rings. Sterile white sporophores frequently develop in culture from sclerotia (FIG. 6). A reddish-brown stromatic crust often develops in culture with small sclerotia arising on it.

This species causes a serious disease of cereals and grasses. It is sometimes collected with *T. idahoensis,* but more frequently occurs alone and more abundantly than that species. The name "snow-scald" has been applied to the disease caused by these two species (**29**) because of their association with snow and the scalded appearance of the plants after the snow melts. The disease occurs both under the snow and as the snow is melting. The plants are covered with a white mycelial growth and the tissue is filled with numerous reddish brown sclerotia.

There is a great deal of confusion in the literature concerning the nomenclature of *Typhula graminum, Sclerotium fulvum,* and *Typhula Itoana.* These names have all been applied to the organism causing the serious disease of cereals and grasses associated with snow and cold weather in the United States, Europe, and Japan. The writer has compared materials and cultures sent to her from Japan and Europe with the organism collected in the United States in the hope of clearing up this confusion.



FIGS. 2–6.

Examination of cultures of the organism obtained from Japan,[15] showed the organism to be identical with the one occurring in the United States, both in sclerotial morphology and type of sporophores obtained from the sclerotia under natural and artificial conditions. This organism, therefore, is *Typhula Itoana* Imai.

Cultures [16] were obtained which causes the same type of disease in northern Europe, and which has been identified as *Typhula graminum* Karsten (**36**). An examination of these sclerotia, which were produced on potato dextrose agar, proved the sclerotial morphology to be identical with that of *Typhula Itoana* Imai. Sporophores have not yet been obtained from this material, and until they are available for comparison with those of *T. Itoana*, a definite synonymy cannot be made. Since the sporophores have been rarely observed in nature by European workers, and since the sclerotia resemble *Sclerotium fulvum* Fries in macroscopic morphology, it is easy to understand the prevalent usage of *Typhula graminum* Karsten as the causal organism of this disease of cereals.

An examination of Roumeguère, Fungi Gall. *1400, Sclerotium fulvum* Fries, C. U., shows the sclerotium to be similar in macroscopic morphology and identical in microscopic morphology with that of *T. Itoana*. That is, the rind is a homogeneous gelatinous layer and the medulla paraplectenchymatous.

However, an examination of sclerotia from type material of *Typhula graminum* Karsten [17] shows the morphology of the sclerotium entirely different from that of *Sclerotium fulvum* and that of *T. Itoana*. That is, the medulla is prosoplectenchymatous with a layer of enlarged thin-walled cells adjacent to the homogeneous gelatinous rind. Furthermore, *T. graminum* is characterized by white sporophores, while *T. Itoana* has rose colored sporophores.

From these observations it appears that *T. Itoana* is a distinct

[15] Sent to us through the courtesy of H. Tasugi, Tokyo, Japan.

[16] Obtained through the courtesy of A. Volk, Königsberg, Germany.

[17] Lent to us by Dr. Harald Lindberg, Helsingfors, Finland.

FIGS. 2–6. Growth of five species of *Typhula* in culture on potato dextrose agar. 2–5, natural size; 6, × 2. 2, *T. idahoensis*, sclerotia formed singly and more or less clustered, 6° C.; 3, *T. variabilis*, sclerotia tending to coalesce, 6° C.; 4, *T. gyrans*, sclerotia in concentric rings, with outer ones immature, 9° C.; 5, *T. intermedia*, sclerotia upon brown stromatic crust, 18° C.; 6, *T. Itoana*, young sterile sporophores developing from the sclerotia, 6° C.

species from *T. graminum* based on morphological comparisons between the two. It seems unwise to draw this distinction too definitely, since the type material of *T. graminum* examined was old and fragmentary. It is advisable to obtain sclerotia of *Sclerotium fulvum* from the Fries collection to ascertain the morphology of the type material before a complete synonymy can be made.

3. **Typhula sphaeroidea** sp. nov.

Sclerotia colore ligno-brunneo paene usque ad nigrum, aliquantum aspera, innata, adhaerentia, simplicia v. acervatim, plana infra, convexa supra, saepe inaequalia, 0.5–1.0 mm., cortex aureus v. rubrus-brunneus, 15–30 μ crassus, compositus e pluribus struibus paraplectenchymatosarum cellarum et extendens incomposite in medullam, medulla (FIG. 43) omnino paraplectenchymata v. hyphis centro laxe complexis quod centrum est cinctum atris et crassimuralibus cellis quasi interiorem corticem facientibus (FIG. 44); sporophori (FIGS. 23, 24) valde clavati v. subglobosi, recti, simplices, fere unus ex uno sclerotio v. orti directo ex myceliis, 1–3 mm. alti, albi, basi rubra-brunnea; clavula globosa, subglobosa v. pyriforma, 0.8–1.5 mm. longa, 0.5–1.5 mm. lata, colore cretae, dein lactea cum arescit, apice fertili, subhymenio incrustato; stipes distinctus, erectus, ad basem crassus, minutate pubescens, 1–2 mm. longus, 0.3–0.5 mm. diametro, albus, basi rubra-brunnea, solidus, incrustatus; basidia (FIG. 49) breva, crassa, abrumpentia, quadrispora, 19.45–45.01 μ longa, 9.73–11.67 μ lata; basidiospori (FIG. 54) ovati, apiculo truncato manifesto, 5.84–8.78 × 11.67–13.62 μ, modus 6.69 × 12.13 μ.

HAB.: In mortuis caudicibus *Rubri* sp. Sporophoris collectis in mense Augusto ortis ex sclerotiis innatis in caudicibus.

HERBARIUM SPECIMENS: C. U. *26754*, N. H., Aug., on dead stems of *Rubus* sp.

NOTES: The fungus grows in culture from 0–25° C., with an optimum temperature of 12–18° C. Mycelial growth is white and appressed or webby. Sclerotia rarely develop in culture on potato dextrose agar. Fertile sporophores develop abundantly from mycelium on the surface of the agar from 12–18° C., are white with a reddish-brown base. Sterile, abnormal, white sporophores also develop in culture at 9–12° C.

4. TYPHULA GYRANS Batsch ex Fries, Obs. Myc. 2: 297–298. 1818.

Clavaria gyrans Batsch, Elenchus Fung. 235. *pl. 28, f. 164a–e.* 1783.

Clavaria granulata Willd. Florae 705. *pl. 17, f. 17.* 1787.

Cnazonaria setipes Corda, in Sturm, Deuts. Fl. Pilze **2**: 55. *pl. 25.* 1829.

Clavaria trichopus Grev. Scott. Crypt. Fl. **1**: 49. *pl. 49.* 1823.

Clavaria setipes Grev. in Loudon, Encycl. 1012–1013. *f. 16181.* 1855.

Typhula stolonifera Quél. Assoc. Fr. Av. Sci. Compte Rendu **15**: 506. *pl. 12, f. 17.* 1883.

ILLUSTRATIONS (in addition to the above): DeBary, Vergl. Morph. Pilze 35. *f. 15 c.* 1887; Pat. Tab. Anal. Fung. **1**: 116. *f. 262, 264.* 1883.

MATERIAL EXAMINED: C. U., Roum. Fungi Gall. *3418 Typhula gyrans* (Batsch) Fries.

Sclerotia natal-brown to clove-brown, nearly black when dry, immersed in substrate, single or coalesced into irregular masses, spherical to subglobose, usually flattened below and convex above, smooth at first, rough when dry, 0.5–3.0 mm. in diameter, shrinking somewhat with age and on drying; rind golden-brown to dark-brown, about 7.5 μ thick made up of strata of hyphae winding around the medulla, surface view showing irregularly fused cells with hyphae running across the surface (FIG. 36), these hyphal layers breaking and sluffing away as the sclerotium matures and increases in size; medulla cartilaginous, paraplectenchymatous (FIG. 45), solid, center sometimes prosoplectenchymatous with hyphae loosely interwoven; sporophores (FIG. 12) clavate, erect to flexuous, twisted, simple, apex round or obtuse, one or more from each sclerotium, 5–15 mm. tall, milk-white, becoming pale olive-buff at maturity, reddish-brown at the base; clavula straight or slightly curved, cylindrical, fusoid or elliptical, 2–5 mm. long, 0.5–1.5 mm. broad, white to pale olive-buff, hollow, more or less filled with loosely interwoven hyphae sparingly incrusted with crystals, subhymenium somewhat more compact with hyphae thickly incrusted with these crystals, hymenuim extending over the apex; on drying, clavula bending down at an acute angle to the stipe, finally becoming parallel to it; stipe very distinct in size from the clavula, flexuous, twisted, weak, smooth at first, later pubescent, especially at base and just below the clavula, 10–16 mm. long, 0.1–1.25 mm. in diameter, fawn to walnut-brown at the base, becoming white above towards the clavula, solid, hyphae heavily incrusted with coarse crystals, especially towards the base, on drying twisting spirally at the top causing a characteristic gyrating movement of the clavula as it bends back parallel to it; basidia

elongate, blunt at the apex, four-spored, 7.78 μ broad, about 20–25 μ long; basidiospores (FIG. 57) obovate, flattened on one side above an inconspicuous pointed apiculus, 3.89–6.22 $\times$ 8.56–11.67 μ, average 4.53 $\times$ 10.03 μ.

HAB.: On dead leaves, petioles, and herbaceous stems on the ground. Sclerotia collected in the autumn.

HERBARIUM SPECIMENS: C. U. *25328*, N. Y., Sept., on dead leaves; *27080*, N. Y., Sept., on *Prunus serotina* leaves and petioles; *27092*, N. Y., Sept., on *Rubus* sp. stems.

NOTES: Because of its apparent resemblance to *T. gyrans*, *Typhula stolonifera* Quélet has been included here in the synonymy. Quélet noted this resemblance and thought it might be an abnormality of *T. gyrans*, since it arose from a brown stolon instead of a sclerotium. The Icones of Quélet and Patouillard show the plant to be identical with *T. gyrans* except for this character. This same phenomenon has been observed many times in these studies of *Typhula*, *i.e.*, the sclerotium may produce a long stolon-like growth from which the sporophore will arise. The stipe itself may be prostrate for a distance before becoming erect due to obstacles in the substratum, thus resembling a stolon.

The fungus grows in culture over a range of 0–25° C. with an optimum temperature of 12–18° C. Mycelial growth is appressed or submerged, forming a cartilaginous mat on the surface of the agar. Sclerotia which appear in 7–14 days are single, rarely coalesced, scattered or in concentric rings (FIG. 4), white to light-buff when young, snuff-brown to clove-brown when mature. Brown stromatic crusts form on the surface of the agar at higher temperatures. Sterile sporophores have never been observed in culture.

5. **Typhula Viburni** sp. nov.

Sclerotia colore cinnamo brunneo usque ad Martem brunneum v. auburno usque ad castaneum brunneum, innataerumpentia, adhaerentia, simplicia v. acervatim, raro coalescentia, plana infra, convexa supra, glabra v. leviter aspera, 0.5–1.0 mm., cortex (FIG. 34) aureus brunneus, 12–20 μ crassus, compositus e diversis struibus hypharum atrarum crassimuris implexarum, extremae cellae distortae et ruptae ut sclerotium crescit, medulla (FIG. 45) cartilaginosa, pseudoparenchymatosa, centro saepe prosoplectenchymatoso, hyphis laxe complexis; sporophori (FIGS. 25, 26) clavati, erecti, recti v. leviter curvi, ad apicem crassi, attenuati infra, simplices, unus ex uno

sclerotio, glabri, 2–5 mm. alti, albi, suffusci ad basem; clavula recta v. curva, cylindrica, fusiforma-ellipsoidea v. ovata, 1.2–2.0 mm. longa, 0.5–1.0 mm. lata, alba, dein pallide brunnea, solida, hyphis laxe implexis, incrustatis, apice fertili; stipes distinctus, erectus, rectus minute pubescens, 4.0–4.5 mm. longus, 0.1–0.2 mm. diametro, albus, base brunnea, solidus, incrustatus; basidia elongata, apice retuso, quadrispora, 20.0–23.5 μ longa, 7.78 μ lata; basidiospori ovati, apiculo acuto, 3.89–4.67 × 7.78–9.73 μ, modus 4.38 × 8.52 μ.

HAB.: In mortuis foliis *Viburni* sp. Sporophoris collectis mense Augusto, orti e sclerotiis in foliis innatis.

HERBARIUM SPECIMENS: C. U. *26753,* N. H., August, on dead leaves of *Viburnum* sp.

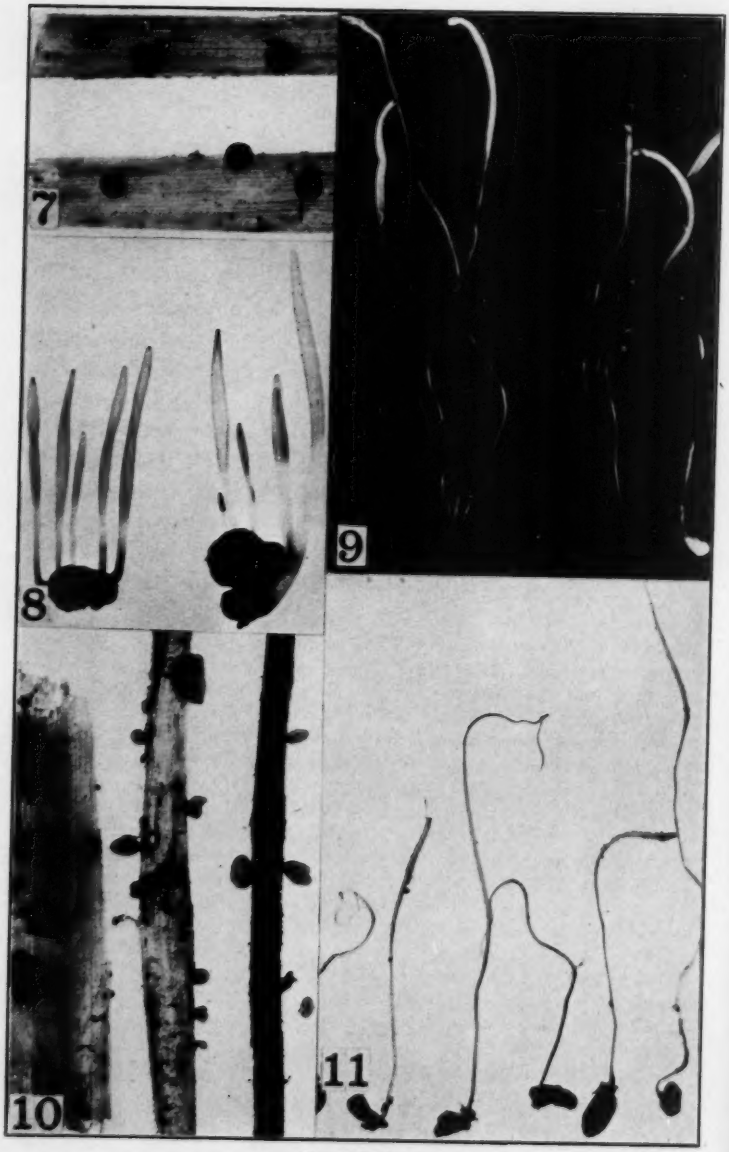
NOTES: This species grows in culture from 0–27° C., with an optimum temperature of 12–18° C. Mycelial growth is appressed to submerged and hydrotic. Sclerotia, which appear in 7–14 days, are single or coalesced, in concentric rings, white to light-buff when young, cinnamon-brown to Mars-brown or chestnut-brown when mature. Stromatic crusts form at higher temperatures. Sterile sporophores frequently develop in culture from either sclerotia or mycelium.

6. **Typhula umbrina** sp. nov.

Sclerotia colore "van dyke" brunneo usque ad castaneum brunneum, dein propre ad nigrum cum arescunt, erumpentia v. superficia, semper simplicia, numquam acervatim, plana infra, convexa supra, glabra prima dein leviter aspera, 0.5–4.0 mm., cortex rubrus-brunneus, 7–12 μ crassus, compositus e gelatinosa strue in exterioribus muris cellarum peripheralim amplificatarum angulatarum detorquearum (FIG. 33), medulla incrustata et prosoplectenchymata, cellis ad peripheriam amplificatis et tenuimuralibus et ad has adiacentibus cellis frequenter paraplectenchymatis (FIG. 39), centro solido; sporophori (FIG. 15) clavati, erecti, recti v. leviter curvi, crescenti gradatim ex tenui basi ad crassum apicem, simplices, unus v. plures ex uno sclerotio, basi minute pubescente, 8–15 mm. alti, albi, v. avellanei supra, hinnulei colore v. ligni brunnei infra; clavula cylindrica, gradatim attenuata e crasso apice in stipem, 3–8 mm. longa, 0.8–1.5 mm. crassa ad apicem, alba v. avellanea, solida, hyphis laxe complexis, incrustata, apice fertili; stipes distinctus, minute pubescens, capillis extensis ad basem, 3–4 mm. longus, 0.2–0.5 mm. diametro, hinnulei colore v. ligni brunnei v. "Rood"-brunneus, basi saepe aliquantum atriori, solidus, incrustatus; basidia elongata, quadrispora, 31.0–39.0 μ longa, 5.83–7.8 μ lata; basidiospori ovati, apiculo inmanifesto, 11.67–15.56 × 3.89–7.78 μ, modus 12.56 × 5.54 μ.

HAB.: In rapis frigore conservatis et in iridum rhizomis.

HERBARIUM SPECIMENS: C. U. *25711,* Br. Col., Apr., on turnips, *25710,* Ottawa, Apr., on leaves and rhizomes of iris.



FIGS. 7–11.

NOTES: The two collections of this fungus were obtained from Dr. F. L. Drayton, Ottawa, Canada, who observes that the organism apparently causes a mild necrosis of suscept tissue. The optimum temperature of the fungus (6–12° C.) indicates that its activity is confined to low temperatures, and it is possible that it is weakly pathogenic.

The fungus grows in culture over a range of 0–18° C. with an optimum temperature of 6–12° C. Mycelial growth is radiating, appressed, somewhat granular and concentrically banded. Sclerotia, which appear in 5–7 days, are always single and never coalesced, have a tendency to form in concentric rings at low temperatures, and to cluster closely together at higher temperatures, are light yellow to tan when young, chestnut brown when mature. No sterile sporophores have been observed in culture.

7. TYPHULA VARIABILIS Riess, Hedwigia **1**: 21. *pl. 3, f. 2c.* 1853.

Lycoperdon Brassicae Bergius, Sv. Vet. Acad. Handl. **26**: 213. 1765.

Tremella sphaerica Gleditsch, Ver. Phys. Bot. Oecon. Abhandl. **2**: 346. 1766.

Lycoperdon subterraneum Haller, Historia **3**: 120. 1768.

Lycoperdon minimum Murray, Comm. Gotting. **3**: 83. 1772.

Lycoperdon oleraceum Pollich, Hist. Pl. **3**: 314. 1777.

Sphaeria Brassicae Dickson, Fasc. Plant Crypt. Brit. **1**: 23. 1785.

Sclerotium semen Tode, Fungi Meckl. **1**: 4. *pl. 1, f. 6a–c.* 1790.

Sclerotium semen (Tode) var. *Brassicae* (Bergius) Fries, Syst. Myc. **2**: 249. 1822.

Typhula lactea Tul. Sel. Fung. Carp. **1**: 106. 1861.

Typhula semen (Tode) Quél. Bull. Soc. Myc. Fr. **24**: 326. *pl. 6, f. 2.* 1877.

FIGS. 7–11. Sclerotia and sporophores of two species of *Typhula*. All × 2. 7, sclerotia of *T. variabilis* on herbaceous stems; 8, young sporophores of *T. variabilis* arising from artificially grown sclerotial masses in diffused daylight; 9, mature sporophores of *T. variabilis* produced under ultra-violet irradiation; 10, sclerotia of *T. phacorrhiza* showing natural habitat on herbaceous stems; 11, mature sporophores of *T. phacorrhiza* arising from single sclerotia in diffused daylight.

ILLUSTRATIONS (in addition to the above): Brefeld, Unters. Gesammt. Myk. **3**: *pl. 8, f. 1–3.* 1877; Bolton, Hist. Fung. *pl. 119, f. 1–2.* 1789; Britz. Hymen. Südb. **5**: *pl. 741, f. 42.* 1885; Corda, Ic. Fung. **3**: *pl. 3, f. 55.* 1839; Henn., in E. & P., Nat. Pfl. **1**: *f. 71m–n.* 1900; Herter, Krypt. der Mark Brandenburg **6**: *f. 16* and *147, f. 2a–c.* 1910; Neveu-Lemaire, Parasit. Pl. Agric. *f. 194.* 1913; Prilleux, Malad. Pl. Agric. **1**: *f. 119, 120.* 1895; Sow. Engl. Fungi **3**: *pl. 393, f. 3.* 1803; Winter, in Rab. Krypt.-Fl. **1**: 301, *293. f. 3–4.* 1884; Zopf, Pilze *f. 79a–b.* 1890.

MATERIAL EXAMINED: C. U., Krieger, Fungi Sax. *478;* H. Sydow, Myc. Germ. *1200.*

Sclerotia (FIG. 7) resembling large mustard seeds, chestnut-brown to almost black, free on surface of substrate, single or coalesced, smooth at first, becoming rough or furrowed, especially when dry or after fruiting, spherical to somewhat flattened, convex on top, flat or concave below, indented at point of attachment of the minute stalk, falling away from the substrate easily when mature, 3–5 by 5–6 mm., rind dark-reddish-brown, 10–15 μ thick, composed of a rough, gelatinous layer on the outer walls of large, irregular and distorted, peripheral cells, medulla prosoplectenchymatous, with cells adjacent to rind enlarged and thin-walled, solid, center either compact or of loosely interwoven hyphae; sporophores (FIGS. 8, 9, 50) clavate, erect, straight or slightly curved, apex acute, tapering below into a slender stipe, simple or branched, one or more arising from each sclerotium, hairy at base, 30–50 mm. tall, olive-buff to smoke-grey, darker at the apex and base, avellaneous to wood-brown when dry or with age, sclerotia forming over surface of old sporophores under moist conditions; clavula cylindrical or somewhat flattened, often longitudinally furrowed, spores frequently collect in balls over the surface giving a warted appearance, 10–20 mm. long, 1–3 mm. broad, olive-buff, tip sterile, darker, of a light greyish-olive, this darker tip very characteristic even in young developing sporophores, old specimens often proliferating to form spur-like branches, hollow, more or less filled with very loosely interwoven septate hyphae, sparingly incrusted with large crystals, subhymenium of compact hyphae, thickly incrusted with these crystals; stipe very distinct in size and color from clavula, minutely pubescent when mature with spreading bristly hairs at the base which clasp the sclerotium, 5–25 mm. long, 0.5–1.0 mm. in diameter, smoke-grey at base and gradually becom-

ing lighter upwards, almost shiny white just below clavula, silky when old or dry, solid, hyphae somewhat incrusted; basidia (FIG. 51) elongate, round at apex, four-spored, 27.23 μ long, 7.78 μ wide, a clamp connection at the base of each basidium; basidiospores (FIG. 55) ellipsoid-fusiform, flattened or slightly incurved on one side above the conical apiculus, 3.89–5.84 $\times$ 10.67–15.56 μ, average 4.3 $\times$ 11.39 μ.

HAB.: On vegetables in cold storage or on overwintered corn fodder, buckwheat straw and various herbaceous stems, leaves, and petioles on the ground. Sclerotia are found in the spring, the sporophores in the autumn, arising from the sclerotia.

HERBARIUM SPECIMENS: C. U. *26952*, N. Y., Mar.–Apr., on buckwheat straw; *2183, 5185, 14459, 27031*, N. Y., Mar.–Apr., on corn stalks and leaves; *5184, 16401, 25666, 27033*, N. Y. and Ottawa, Jan.–Apr., on herbaceous stems and leaves; *27030, 27032*, N. Y. and Montreal, Dec.–Apr., on celery in cold storage; *12256*, Mo., Sept., with clover seed.

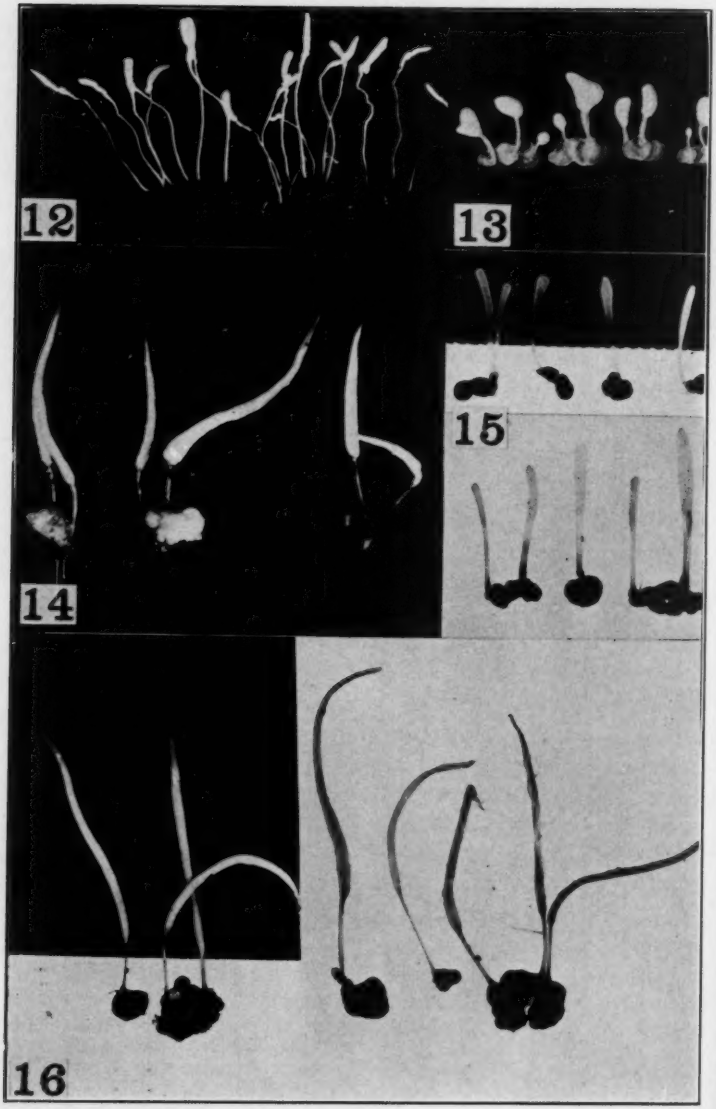
NOTES: A very destructive disease of sugar beets and potatoes caused by *T. variabilis* has been reported a number of times from European countries and from the Azores (**2, 7, 22, 27, 31, 35**). It has also been reported weakly pathogenic on stored celery at the University of Montreal and at Cornell University.[18] Artificial inoculation experiments have produced infections on beets, potatoes, asparagus rhizomes and stored celery (l. c.).

Growth in culture occurs over a range of 0–21° C. with an optimum temperature 12–15° C. Mycelial growth is appressed, woolly to powdery and inconspicuous. Sclerotia are produced in 7–14 days, are single or coalesced into masses (FIG. 3), white when young, mahogany-red to chestnut-brown when mature. At 21° C. a brown stromatic crust is formed over which a few, small sclerotia develop in concentric rings. Sterile white sporophores occasionally develop in culture.

8. **Typhula virgata** sp. nov.

Sclerotia colore verono-brunneo, innata-erumpentia, simplicia v. frequenter acervatium, globosa v. subglobosa v. plana, 0.5–0.8 mm., cortex aureus brun-

[18] Robert White-Stevens, Department of Vegetable Crops, Cornell University. (Unpublished.)



FIGS. 12–16.

neus, 5–10 μ crassus, compositus e gelatinosa strue in exterioribus muris cellarum peripheralium incompositarum amplificatarum, medulla prosoplectenchymata, cellis adiacentibus ad corticem amplificatis et tenuimuralibus praeditis, centro solido, hyphis laxe complexis; sporophori (FIG. 21) virgati, cylindrici, recti v. leviter curvi, ad apicem rotundi v. crassi, decrescentes gradatim deorsum, simplices, fere unus ex uno sclerotio sive e mycelio sive e stromaticis crustis, 4–12 mm. alti, toti albi; clavula recta v. curva, filiforma v. crassa, obtusa v. rotunda ad apicem, 5–11 mm. longa, 1.5 mm. lata, solida, hyphis incrustatis, apice fertili; stipes indistinctus praeterquam ad maturitam, rectus v. curvus, minute pubescens, 2–6 mm. longus, 0.1–0.2 mm. diametro, solidus, aliquantum incrustatus; basidia elongata, bi- v. quadrispora (FIG. 1, *b, c*) 25–30 μ longa, 5.8–7.8 μ lata; basidiospori ellipsoidei, apiculo acuto, 3.89–5.84 × 9.27–15.17 μ, modus 4.26 × 12.24 μ.

HAB.: In hibernatis herbaceis caudicibus. Sporophoris ortis in autumno ex sclerotiis innatis in caudicibus.

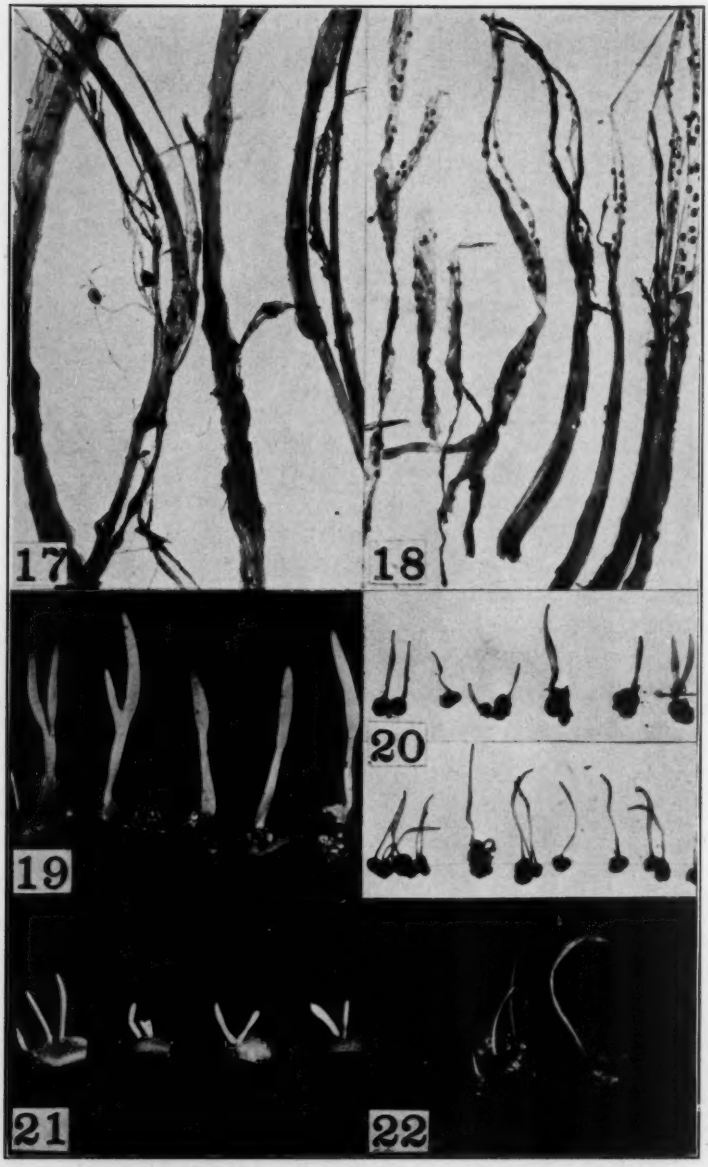
HERBARIUM SPECIMENS: C. U. *25158,* N. Y., Sept., on overwintered herbaceous stems.

NOTES: The fungus grows in culture from 0–21° C. with an optimum temperature of 12–15° C. Mycelial growth is thin and hydrotic at first, later forming dark, tough, irregular stromatic crusts. Sclerotia, which appear in 7–12 days, are single or coalesced, single at 15–18° C., spherical or irregular, flat or concave below and convex above, white to light-buff when young, verona-brown when mature. No sterile sporophores have been observed in culture.

9. **Typhula pertenuis** sp. nov.

Sclerotia colore "bister" prope ad nigrum, superficia, simplicia v. acervatim, glabra dein aspera globosis v. subglobosis, 2–3 mm., cortex valde aureus brunneus, 7–10 μ crassus, compositus ex aspera et gelatinosa strue in exterioribus muris cellarum peripheralium amplificatarum incompositarum detroquearum, medulla prosoplectenchymata, cellis adiacentibus ad corticem amplificatis et tenuibus muris praeditis, centro solido, hyphis laxe complexis;

FIGS. 12–16. Sporophores of five species of *Typhula* from artificially grown sclerotia. All × 2. 12, *T. gyrans* from sclerotial masses under ultra-violet light; 13, *T. latissima* from sclerotial masses in diffused daylight; 14, *T. subulata* from sclerotial masses in diffused daylight; 15, *T. umbrina* from single sclerotia in diffused daylight; 16, *T. intermedia* from sclerotial masses in diffused daylight, those on the right showing method of clavula branching in old specimens.



FIGS. 17–22.

sporophores (FIG. 22) elongati-clavati, tenuissima, erecti v. nonnihil prosterni, rotundi ad apicem, attenuati infra, simplices, fere unus ex uno sclerotio, sive orientes e mycelio sive e stromaticis crustis, 6–30 mm. alti, toti albi dein avellanei cum senescunt v. arescunt; clavula recta v. curva, rotunda ad apicem, 8–15 mm. longa, 1.0–3.0 mm. lata, solida, hyphis aliquantum incrustatis, apice fertili v. sterili; stipes distinctus, rectus v. curvus, pubescens, 4–10 mm. longus, 0.5–1.5 mm. diametro, solidus, aliquanutm incrustatus; basidia elongata, quadrispora, circiter 25 μ longa, 7.78 μ lata; basidiospori ovati, apiculo acuto, 3.89–5.84 $\times$ 7.78–12.45 μ, modus 4.9 $\times$ 9.18 μ.

HAB.: Per humum. Sporophoris collectis in autumno orti e sclerotiis.

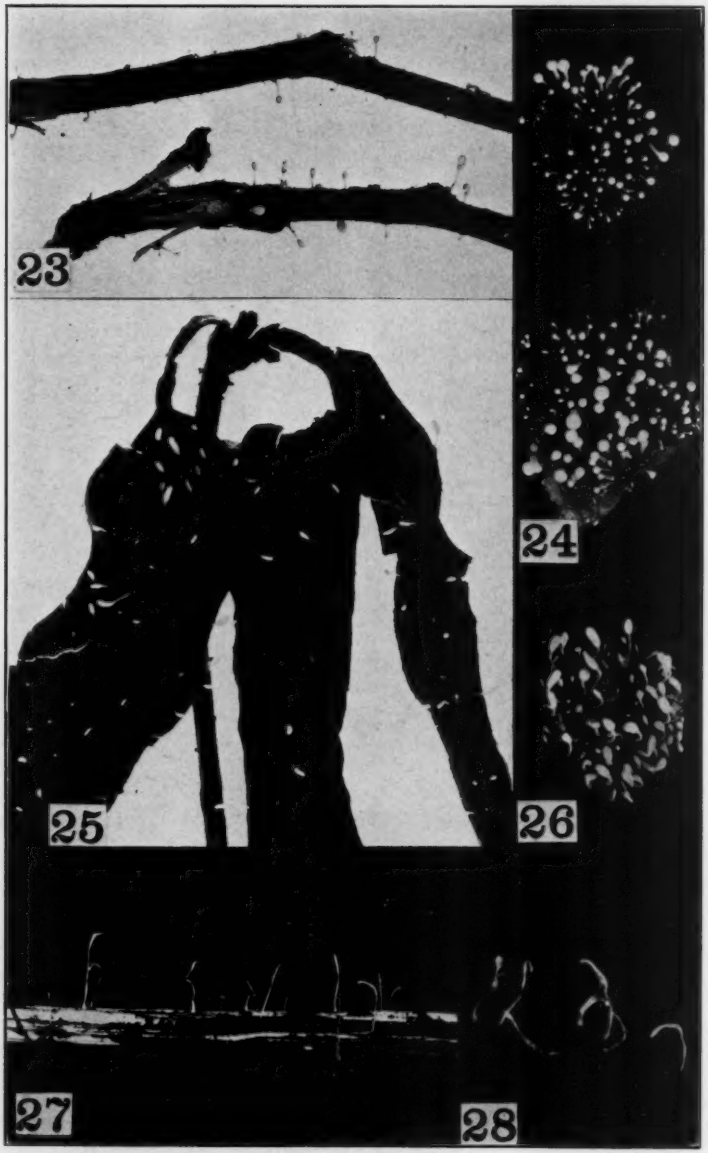
HERBARIUM SPECIMENS: C. U. *27284*, N. Y., Sept., on soil.

NOTES: The fungus grows in culture from 0–21° C., with an optimum temperature of 15–18° C. Mycelial growth is white, granular or webby, and brown stromatic crusts develop on the surface of the agar at 15–21° C. Sclerotia, which appear in 5–7 days, are white when young, bister when mature, are single, clustered, or frequently coalesced and irregular, convex above, flat or concave below. Sterile sporophores have never been observed in culture.

10. TYPHULA INTERMEDIA Appel & Laubert, Arb. Anst. Landw. Forstwirtsch. **5**: 153. 1905.

Sclerotia mahogany-red to chestnut-brown or van dyke-brown to nearly black, superficial or erumpent on substrate, always single, never coalesced, smooth and glistening when moist, rough and dull when dry, spherical to sub-globose, falling away from substrate when mature, 0.5–1.0 $\times$ 1.5–3.5 mm., rind (FIG. 37) very dark reddish-brown, golden toward the medulla, 11–15 μ thick, composed of a rough tuberculate gelatinous layer on the outer walls of irregular and distorted peripheral cells, in surface view the tubercles appear in rosettes, medulla (FIG. 41) prosoplectenchymatous, solid, with hyphae often more loosely interwoven in the center; sporophores (FIG. 16) clavate, erect to flexuous, frequently prostrate,

FIGS. 17–22. Sclerotia and sporophores of four species of *Typhula*. 17, 19–22, $\times$ 2; 18, natural size. 17, sclerotia of *T. Itoana* embedded in tissue of *Dactylis glomerata;* 18, sclerotia of *T. idahoensis* embedded in tissue of *Agropyron cristatum;* 19, sporophores of *T. Itoana* arising from artificially grown sclerotial masses in diffused daylight; 20, sporophores of *T. idahoensis* arising from single sclerotia in diffused daylight; 21, sporophores of *T. virgata* arising from mycelial masses on surface of agar in diffused daylight; 22, sporophores of *T. pertenuis* arising from sclerotia in diffused daylight.



FIGS. 23–28.

simple, one or more from each sclerotium, 18–40 mm. tall, entirely white, sterile, filiform, branched sporophores often arising from the sclerotia instead of the normal clavate ones; clavula straight to slightly curved, cylindrical, tapering at the apex, 6–20 mm. long, 0.5–1.0 mm. in diameter, hollow, made up of loosely interwoven hyphae incrusted with crystals, hymenium continuous over apex; stipe distinct in size from clavula, weak, rarely erect, usually flexuous or prostrate from weight of clavula, somewhat pubescent, 5–15 mm. long, 0.3–1.0 mm. in diameter, solid, hyphae incrusted with crystals; basidia elongate, slender, four-spored, 25–30 μ long, 9–10 μ wide at the apex; basidiospores ellipsoid, flattened on one side above a prominent pointed apiculus, 11.67–15.95 $\times$ 4.28–7.78 μ, average 13.88 $\times$ 6.19 μ.

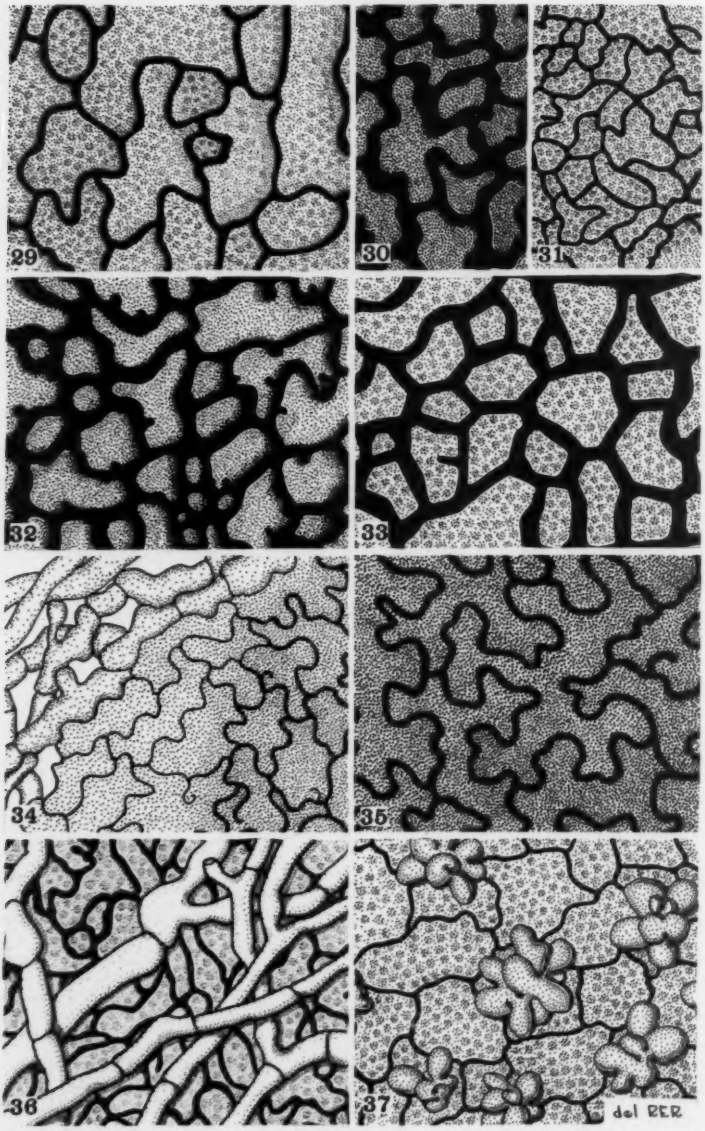
HAB.: On fallen overwintered leaves, petioles, and herbaceous stems. Sclerotia are found in the spring, the sporophores in the autumn arising from the sclerotia.

HERBARIUM SPECIMENS: C. U. *25234*, N. Y., Mar., on herbaceous stems; *26951*, N. Y., Apr., on buckwheat straw; *25235*, N. Y., Feb.–Mar., on *Populus* sp. and *Acer* sp. leaves.

NOTES: A very striking character of *T. intermedia* is the frequent production of sterile, white, filiform, branched sporophores from the sclerotia instead of the usual clavate fertile sporophores. This character is given particular attention by Appel and Laubert in their original description of the species. This tendency to produce sterile sporophores is particularly apparent under ultra-violet irradiation.

The fungus grows in culture over a range of 0–21° C., with an optimum temperature of 12–15° C. Mycelial growth is fan-shape and woolly. Sclerotia which appear in 7–14 days, are always single, never coalesced, white when young, chestnut-brown to van dyke-brown when mature. A brown stromatic crust is formed at 15–21° C. over which a few small sclerotia develop. Sterile white sporophores are frequent in culture from 6–15° C.

FIGS. 23–28. Sporophores of three species of *Typhula* arising from sclerotia embedded in the natural substrate, *23*, *25*, *27*, and from artificially grown sclerotial masses, *24*, *26*, *28*. All $\times$ 2. *23*, *T. sphaeroidea* on stems of *Rubus* sp.; *24*, *T. sphaeroidea* produced under ultra-violet irradiation; *25*, *T. Viburni* on leaves of *Viburnum cassinoides;* *26*, *T. Viburni* produced under ultra-violet irradiation; *27*, *T. Athyrii* on stems of *Athyrium angustum;* *28*, *T. Athyrii* produced in diffused daylight.



FIGS. 29–37.

11. **Typhula idahoensis** sp. nov.

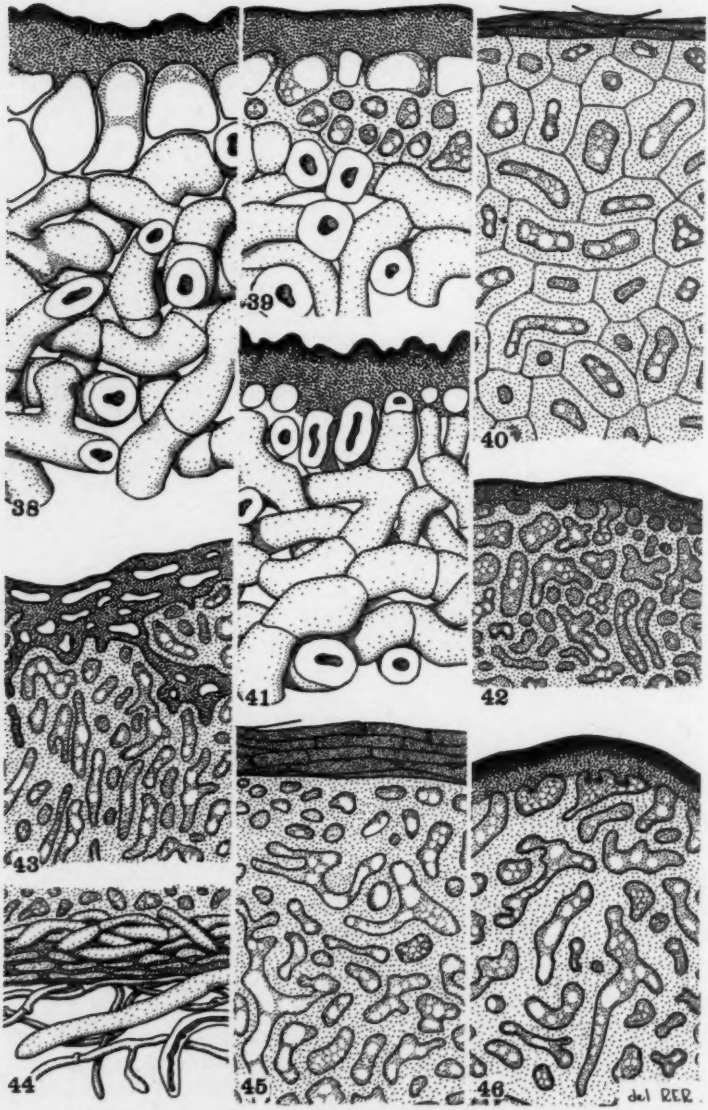
Sclerotia (FIG. 18) colore castaneo brunneo v. ossibrunneo paene usque ad nigrum, innata dein erumpentia v. superficia, semper simplicia, nunquam acervatim, globosa v. subglobosa, plana infra, convexa supra, glabra, nitida dein obscura, 0.5–0.9 × 1–2 mm., cortex valde rubrus-brunneus, 5–20 μ crassus, compositus e gelatinosa strue in exterioribus muris cellarum peripheralium incompositarum amplificatarum (FIG. 29), medulla omnino prosoplectenchymata, centro solido, hyphis laxe complexis; sporophori (FIG. 20) clavati, erecti, recti v. leviter curvi, simplices v. raro ramosi, glabri, ad apicem crassi, rotundi v. acuti, unus v. plures ex uno sclerotio, sive orientes directo e mycelio, sive e stolonibus orits e sclerotiis et crescentibus per superficiem humi, 5–10 mm. alti, hinnulei colore v. ligni brunnei, clavula stipe pallidior; clavula recta, elongata-fusiforma, cylindrica, saepe crassa ad apicem, 4–7 mm. longa, 0.5–1.5 mm. lata, vinacea-brunnea v. hinnulea- v. lignea-brunnea, apice atriori, inanis seu hyphis laxe complexis, incrustata, apice sterili seu fertili; stipes distinctus, rectus v. aliquantum flexilis, glabrus v. leviter pubescens ad basim, 2–5 mm. longus, 0.1–0.5 mm. diametro, bistri colore v. umbri v. brunnei "van dyke," solidus, incrustatus; basidia elongata, crassa ad apicem, cellis confibula coniunctis ad basem, quadri- sexti- v. octospora (FIG. 1, *c–e*), 27.0–31.5 μ longa, 5.8–7.78 μ lata; basidiospori ovati v. ellipsoidei, apiculo inmanifesto, 3.8–7.78 × 8.17–13.61 μ, modus 4.55 × 10.51 μ.

HAB.: Pathogeniti in foliis et caudicibus *Tritici vulgaris* et *Agropyri cristati*. Sclerotiis vere collectis post nives solutas, sporophoris in autumno ortis ex sclerotiis.

HERBARIUM SPECIMENS: C. U. *25316, 27220, 27221, 27222,* Ida., Apr.–May, *25153,* Mont., Apr., on *Triticum vulgare; 27223,* Ida., May, on *Agropyron cristatum.*

NOTES: The organism grows in culture over a range of 0–18° C., with an optimum temperature of 9–12° C. Mycelial growth is abundant, fluffy and concentrically banded. Sclerotia, which appear in 5–10 days, are clustered or in concentric rings, always single, never coalesced into masses (FIG. 2), light-amber when young, chestnut-brown when mature. Sterile brown sporophores develop from sclerotia abundantly in culture.

FIGS. 29–37. Surface views of sclerotia of nine species of *Typhula* showing characteristic morphology of peripheral cells composing the rind. All × 450. *29*, irregular thin-walled cells of *T. idahoensis;* 30, irregular thick-walled cells of *T. Itoana;* 31, very small irregular cells of *T. Athyrii;* 32, irregular thick-walled cells of *T. variabilis;* 33, angularly thickened walls of *T. umbrina;* 34, young sclerotium of *T. Viburni* showing the development from loosely intertwined distinct hyphae to fused thick-walled cells composing the mature rind; 35, very irregularly distorter peripheral cells of *T. phacorrhiza;* 36, mature rind of *T. gyrans* with adhering intertwining peripheral hyphae; 37, tuberculate rind of *T. intermedia.*



FIGS. 38–46.

This species causes a disease of cereals and grasses similar to that caused by *T. Itoana*. Sclerotia of the two fungi are often collected in the same field but are readily distinguished by their color.

12. **Typhula Athyrii** sp. nov.

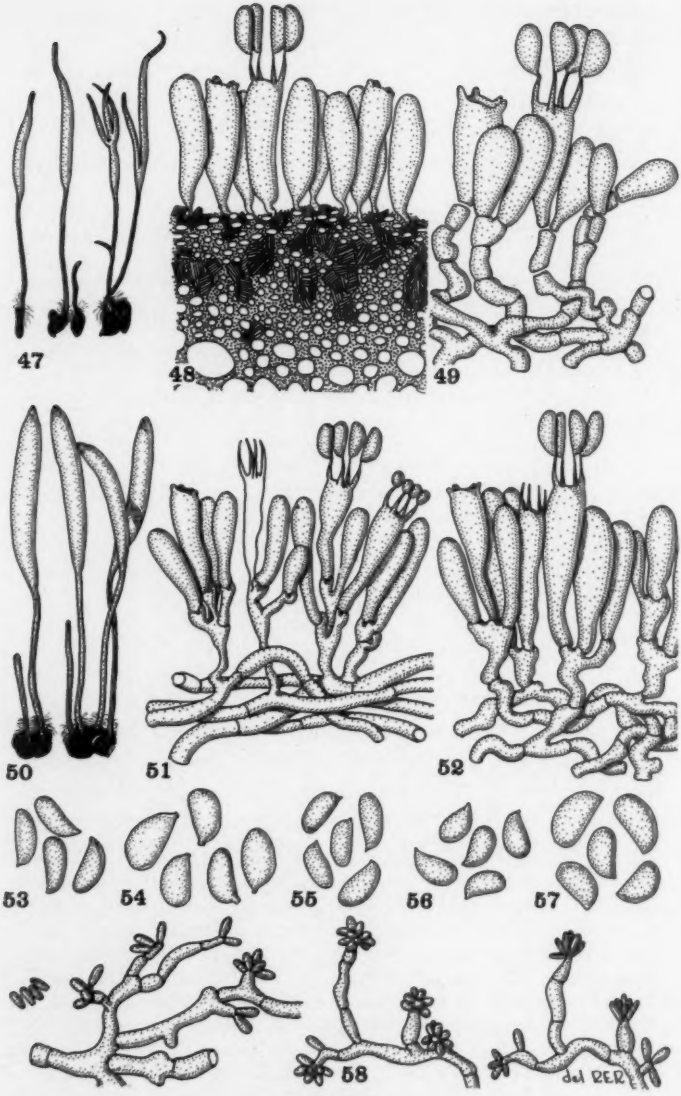
Sclerotia colore argillaceo usque ad fulvum olivem v. gayrophyllono brunneo, innata-erumpentia, simplicia v. acervatim, globoso v. elongata, convexa supra, plana v. concava infra, 0.5–0.7 × 1.0–1.5 mm., cortex aureus flavus, 7–10 μ crassus, compositus ex aspera et gelatinosa strue in exterioribus muris cellarum peripheralim leviter amplificatarum (FIG. 31), medulla incrustata omnino prosoplectenchymata, centro solido, hyphis laxe complexis; sporophori (FIGS. 27–28) clavati, erecti v. flexiles, recti v. leviter curvis, ad apicem rotundi, attenuati infra, simplices v. frequenter ramosissimi, basi pubescente, unus v. plures ex uno sclerotio, sive orientes e stromaticis crustis, 4–15 mm. alti, toti albi, dein sublutacei cum senescunt v. arescunt; clavula cylindrica, recta v. curva, 3–7 mm. longa, 0.5–2.5 mm. lata, solida, apice fertili, hymenio incrustato; stipes distinctus, rectus v. curvus, minute pubescens, 2–5 mm. longus, 0.5–1.0 mm. diametro, gradatim crescens in clavulam, non incrustatus; basidia elongata, quadrispora, circiter 30 μ longa, 8 μ lata; basidiospori fusiformi-ellipsoidei, apiculo acuto, 3.89–5.8 × 7.78–2.84 μ modus 4.12 × 11.06 μ.

HAB.: In hibernatis caudicibus *Athyrii angusti*. Sporophoris collectis autumno orti e sclerotiis.

HERBARIUM SPECIMENS: C. U. *24900*, N. Y., Sept., on *Athyrium angustum*.

NOTES: The fungus grows in culture over a range of 0–25° C., with an optimum temperature of 18–21° C. Mycelial growth is appressed and scanty. Sclerotia, which appear in 5–10 days, are single or coalesced, white to light-buff when young, clay to tawny-olive when mature. Brown stromatic crusts are frequent in culture. Sterile sporophores have never been observed in culture.

FIGS. 38–46. Sections through sclerotia of eight species of *Typhula* showing morphology of medulla and rind. All × 450. 38, prosoplectenchymatous medulla and row of enlarged thin-walled cells adjacent to gelatinous rind of *T. variabilis;* 39, *T. umbrina* with interior of sclerotium prosoplectenchymatous and outer portion paraplectenchymatous with enlarged thin-walled hyphae adjacent to gelatinous rind; 40, *T. Viburni* with medulla pseudoparenchymatous and rind made up of intertwining peripheral hyphae; 41, prosoplectenchymatous medulla and gelatinous rind of *T. intermedia;* 42, paraplectenchymatous medulla and homogeneous gelatinous rind of *T. Itoana;* 43 and 44, periphery and center of *T. sphaeroidea* showing paraplectenchymatous medulla and rind with center of sclerotium bounded by an inner rind-like area; 45, paraplectenchymatous medulla and rind of intertwining peripheral hyphae of *T. gyrans;* 46, paraplectenchymatous medulla and homogeneous rind of *T. phacorrhiza*.



FIGS. 47–58.

13. **Typhula latissima** sp. nov.

Sclerotia colore ossibrunneo, innata-erumpentia, simplicia v. acervatim, globosa v. subglobosa v. plana et inaequalia, 1.5–2.5 × 2.5–3.0 mm., cortex valde rubrus-brunneus, 10–15 μ crassus, compositus ex aspera et gelatinosa strue in exterioribus et inaequalibus muris amplificatarum peripheralium cellarum, medulla omnino prosoplectenchymata, centro solido, hyphis laxe complexis; sporophori (FIG. 13) clavati, erecti v. flexiles, rotundi v. crassi ad apicem, statim in tenues stipes decrescentes, simplices, unus v. plures ex uno sclerotio, 6–18 mm. alti, colore albo v. palide olivo-brunneo, dein sublutacei ut senescunt aut arescunt; clavula recta v. curva, cylindrica v. subglobosa v. plana, rotunda ad apicem, 4–8 mm. longa, 0.8–2.0 mm. lata, colore albo v. pallide olivo-brunneo, nigrescens ut senescit, solida, hyphis incrustatis, ad apicem fertilis; stipes distinctissimus, erectus v. flexilis, pubescens, basi crassa, 3–10 mm. longus, 0.1–0.5 mm. diametro, solidus, hyphis nonnihil incrustatis; basidia elongata, quadrispora, circiter 30 μ longa, 8 μ lata; basidiospori ovati, apiculo acuto, 3.89–7.78 × 9.72–15.17 μ modus 4.12 × 10.66 μ.

HAB.: In hibernatis caudicibus *Typhae latifoliae*. Sporophoris collectis in autumno ortis ex sclerotiis.

HERBARIUM SPECIMENS: C. U. *25157*, N. Y., Sept., on *Typha latifolia*.

NOTES: The fungus grows in culture from 0–25° C. with an optimum temperature of 12–15° C. Mycelial growth is scanty and appressed, and dark stromatic crusts form at all temperatures. Sclerotia which appear in 5–10 days, show a strong tendency to coalesce, are light-buff when young, army-brown to bone-brown when mature. No sterile sporophores have been observed in culture.

FIGS. 47–58. Sporophores, basidia, basidiospores, and microconidia of five species of *Typhula*. 47 and 50 natural size; 48, 49, 51–58 × 450. 47, habit sketch of sporophores of *T. phacorrhiza* arising from single sclerotia; 48, section through clavula of *T. phacorrhiza* showing cylindrical basidia arising from a pseudoparenchymatous subhymenial layer heavily incrusted with dark crystals; 49, fragmentation of basidial and hyphal cells of *T. sphacroidea;* 50, habit sketch of sporophores of *T. variabilis* arising from single sclerotia; 51, basidia of *T. variabilis* showing clamp connections at the base of each basidium; 52, basidia of *T. Itoana* showing broadened basal cells without clamp connections; 53, fusiform spores with pointed apiculus of *T. phacorrhiza;* 54, ovoid spores with truncate apiculus of *T. sphacroidea;* 55, ovoid spores with obconical apiculus of *T. variabilis;* 56, ovoid spores with pointed apiculus of *T. Itoana;* 57, ovoid spores with inconspicuous apiculus of *T. gyrans;* 58, microconidia of *T. Itoana* arising from lateral branches on old mycelium.

14. **Typhula subulata** sp. nov.

Sclerotia colore sternutamenti brunneo, innata-erumpentia, simplicia v. frequenter acervatim, globosa v. elongata, plana infra, convexa supra, glabra dein aspera aut arescunt, 2.0–2.5 × 2.0–2.8 mm., cortex aureus brunneus, 10–15 μ crassus, compositus ex aspera et gelatinosa strue in exterioribus muris cellarum peripheralium leviter amplificatarum, medulla omnino prosoplectenchymatosa, centro solido, hyphis laxe complexis; sporophori subulati (FIG. 14), acutissimi, recti usque ad curvi, simplices, unus ad tres ex uno sclerotio, 9–18 mm. alti, colore pallidulo v. plane pallido, stipes colore atrior; clavula recta v. leviter curva, latissima ad basem, diminuens in acutissimum sterilem apicem, 8–13 mm. longa, 0.5–2.0 mm. lata, colore pallidulo v. plane pallido, solida, hyphis laxe complexis et incrustatis; stipes distinctus, glabrus, 3–5 mm. longus, 0.1–0.2 mm. diametro, colore leviter brunneo (anglice "buff") usque ad ligni brunneum, solidus, nonnihil incrustatus; basidia elongata, quadrispora, circiter 30 μ longa, 8 μ lata; basidiospori ellipsoidei, apicula acuto, 7.0–7.78 × 12.45–15.56 μ, modus 7.37 × 13.85 μ.

HAB.: In mortuis foliis et herbis in autumno. Sclerotiis in autumno collectis.

HERBARIUM SPECIMENS: C. U. *25159,* Manitoba, Sept., on dead leaves and grass.

NOTES: The fungus grows in culture from 0–21° C., with an optimum temperature of 12–15° C. Mycelial growth is abundant, coarse and concentrically banded at 18–21° C. Sclerotia, which appear in 5–7 days, are single or coalesced, in concentric rings, white when young, snuff-brown when mature. Sterile brown sporophores frequently develop in culture from sclerotia or myceliae mats. Stromatic crusts appear on the surface of the agar at temperatures of 12° C. or above.

LITERATURE CITED

1. **deBary, A.** Vergl. Morph. Pilze, I–XVI + 1–558. 1884.
2. **Bensaude, Mathilde.** Diseases of economic plants in the Azores. Kew Bull. Misc. Inform. **1926:** 381–389. 1926.
3. **Berkeley, M. J.** Out. Brit. Fungol. 1–442. 1860.
4. **Bokura, U.** (Japanese title.) Investigation on *Typhula graminum* Karst. Jour. Plant Prot. Japan **13:** 476–489. 1926.
5. **Bourdot, H. & Galzin, A.** Hyménomycètes de France, I–IV + 1–761. 1927.
6. **Brefeld, Oscar.** Botanische Untersuchungen über Schimmelpilze. III. Basidiomyceten, I–IV + 1–226. 1877.
7. **Brizi, Ugo.** La *Typhula variabilis* Riess e il mal dello Sclerozio della barbabietola da zucchero. Accad. Lincei **2: 15:** 749–754. 1906.
8. **Coker, W. C.** The Clavarias of the United States and Canada, 1–209. 1927.

9. **Esmarch, F.** Die *Typhula*-Fäule des Getrides. Kranke Pflanze **7:** 159–161. 1930.
10. **Fries, E. M.** Obs. Myc. I–X + 1–372. 1818.
11. **Fries, E. M.** Syst. Myc. **1:** I–LVII + 1–520. 1821.
12. **Fries, E. M.** Epicr. Myc. I–XII + 1–610. 1838.
13. **Fries, E. M.** Hymen. Eur. 1–755. 1874.
14. **Fuckel, L.** Symb. Myc. 1–459. 1869.
15. **Heald, F. D.** *Sclerotium rhizodes* Auers. U. S. Plant. Ind. Bur. Plant Disease Rep., Suppl. **35:** 270. 1924.
16. **Hennings, P.** Hymenomycetineae. *In* E. & P. Nat. Pfl. **1:** 105–276. 1900.
17. **Hungerford, C. W.** A serious disease of wheat caused by *Sclerotium rhizodes* in Idaho. Phytopathology **13:** 463–464. 1923.
18. **Imai, S.** Nisan Nosakumotsu no *Typhula*-byo ni tsuite. (On some *Typhula*-diseases of agricultural plants.) Nihon Shokubutsu-byorigakkai-ho. (Ann. Phytopath. Soc. Japan) **2:** 386. 1931.
19. **Killermann, S.** Clavariaceae. *In* E. & P. Nat. Pfl. **6:** 151–158. 1928.
20. **Matsumoto, T.** (Japanese title.) On the sclerotial disease accompanying the so-called winter injury of barley. Jour. Plant Prot. Japan **15:** 1–6. 1928.
21. **Müller, K. R.** Über das auftreten der *Typhula*-fäule an Wintergerste und-Reggen in der Provinz Sachsen. Deutsche Landw. Presse **57:** 234. 1930.
22. **Neuwirth, F.** Die Mikromyzeten der Rübenwurzel im Jahre 1924. (The Micromycetes of beetroots in the year 1924.) Zeitschr. für Zuckerind. **49:** 403–410; 479–486, *f. 1–18.* 1925. (Abstract: Rev. Appl. Mycol. **5:** 13. 1926.)
23. **Pape, H.** Krankheiten und Schädigungen der Getreidepflanzen im Jahre 1921. Mitt. Biol. Reichsanst. Land-w. Forstwirtsch. **29:** 127–139. 1926.
24. **Persoon, C. H.** Commentatio de Fungis Clavae-formibus, 1–124. 1797.
25. **Persoon, C. H.** Syn. Fung., I–XXX + 1–706. 1801.
26. **Persoon, C. H.** Mycologia Europaea, 1–356. 1822.
27. **Rambousek, F.** Berichte des Forschungs-Institutes der čsl. Zucker-industrie 1917. Die Rüben-Krankheiten in der Cechoslovakei 1923. (Reports of the research institute of the Czecho-Slovakian sugar industry 1917. Beet diseases in Czecho-Slovakia 1923.) Zeitschr. für Zuckerind. **69:** 197–201. 1925. (Abstract: Rev. Appl. Mycol. **4:** 521. 1925.)
28. **Reichard, H. W.** *Clavaria phacorrhiza.* Schrift. Berl. Ges. Nat. Fr. **1:** 315. *pl. I, f. 4–5.* 1780 .
29. **Remsberg, R. E. & Hungerford, C. W.** Certain sclerotium diseases of grains and grasses. Phytopathology **23:** 862–874, *f. 1–4, table 1.* 1933.
30. **Saccardo, P. A.** Flora Italica Cryptogama **15:** 577–1386. 1916.
31. **Schmidt, E. W.** Zwei seltene Rübenschädlinge. (Two rare beet diseases.) Die Deutsche Zuckerind. **58:** 17–18. *f. 1–6.* 1933. (Abstract: Rev. Appl. Mycol. **12:** 416. 1933.)

32. **Schroeter, J.** Krypt. Fl. Schles. **3**: 1–814. 1889.
33. **Tasugi, H.** On the snow-rot (Yukigusare) fungus, *Typhula graminum* Karsten, of graminaceous plants. Jour. Imper. Agr. Exp Sta., Nishigahara, Tokyo **1**: 41–56. *pl. VI–VII.* 1929.
34. **Tasugi, H.** On the physiology of *Typhula graminum* Karst. Jour. Imper. Agr. Exp. Sta. **2**: 443–458, *tables 1–4, f. 1, pl. XXVII–XXVIII.* 1935.
35. **Voglino, P.** Il mal dello sclerozio rosso della Barbabietola e della Patata. (The red sclerotium disease of the beet and potato.) La Difesa delle Piante, Torino **6**: 1–8. *f. 1–2.* 1929. (Abstract: Rev. Appl. Mycol. **8**: 597. 1929.)
36. **Volk, A.** Untersuchungen über *Typhula graminum* Karst. Zeitschr. für Pflanzenkrankheiten **47**: 338–365, Abb. 1–14, *tables 1–5.* 1937.
37. **Wilson, J. K.** Calcium hypochlorite as a seed sterilizer. Am. Jour. Bot. **2**: 420–427. 1915.
38. **Winter, G.** *In* Rab. Krypt. Fl. **1**: I–VIII + 1–924. 1884.
39. **Young, P. A. & Morris, H. E.** Sclerotium root rot (*Typhula graminum* Karst.). U. S. Plant Ind. Bur. Plant Disease Rep. Suppl. **69**: 127. 1929.
40. **Young, P. A.** Sclerotium blight (*Typhula graminum*). U. S. Plant Ind. Bur. Plant Disease Rep. **13**: 70. 1929.
41. **Young, P. A.** Sclerotium blight of wheat. Phytopathology **27**: 1113–1118. *f. 1–2.* 1937.

EXPLANATION OF FIGURES

All drawings were made with the aid of a camera lucida. The photographs were made by W. R. Fisher, photographer for the Plant Pathology Department, Cornell University.

CULTURAL AND GENETICAL STUDIES OF CERTAIN AGARICS[1]

JOHN B. ROUTIEN

This paper deals with studies of certain Agarics for the purpose of finding a medium upon which they would form typical fruiting-bodies and to determine the type of "sexuality" possessed by each species.

CULTURAL STUDIES

Materials and methods

Tissue cultures were secured of the following species:[2] *Coprinus atramentarius* Fries, *C. comatus* Fries, *C. fimetarius macrorhizus* Fries, *C. micaceus* Fries, *C. plicatilis* Fries, *C. quadrifidus* Peck, *C. radians* Fries, *C. radiatus* Fries, *C. semilantanus* Peck, *Galera crispa* Longyear, *G. tenera* (Fries) Quél., *Panaeolus campanulatus* (Fries) Quél., *P. retirugis* (Fries) Quél., *P. solidipes* (Fries) Quél., *Psilocybe subviscida* Peck, *Stropharia semiglobata* (Fries) Quél.

The stock cultures of these fungi were grown on potato malt-extract agar, and transfers were made from this to the eighty-seven media that were tested either in test-tubes or Erlenmeyer flasks for their value for the growth of the fungi and the production of fruiting-bodies.

There were five general types of media: those consisting of more or less unchanged, natural substances; those containing some known carbohydrate for the food supply; those consisting of potato malt-extract agar to which were added poisons or weak antiseptics; those consisting of potato malt-extract agar to which

[1] This is an abbreviated form of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany of Michigan State College.

[2] *Coprinus fimetarius macrorhizus* Fries and the species described by Peck and Longyear have the author citations that are given by Kauffman (**12**). The works of Fries (**5, 6, 7, 8, 9**), Gillet (**10**), Karsten (**11**), and Quélet (**13**) were used to determine the authors for the other species.

"growth-promoting" substances were added; and those which were treated in some manner to modify the physical conditions.

RESULTS

On the following media the growth was very poor or entirely lacking: decayed wood, sawdust, horse-dung, grass, horse-dung straw mixture, sand horse-dung decayed cottonwood, dung-extract agar, potatoes, malt peptone agar, dung-extract potato malt agar, modifications of Clausen's, Leonian's, Tubeuf's, Duggar's and Piefer, Humphrey and Acree's agar media, potato raffinose agar, potato mannose agar, sucrose corn-starch agar, Czapek's glycerine agar, oatmeal agar, and some of the media that were treated to obtain a change in the physical conditions.

Typical fruiting-bodies of a number of the species were formed on the following media: straw malt-extract, straw potato malt-extract, potato malt-extract agar, potato glucose agar.

The modification of Etter's medium (**4**) was good for the production of fruiting-bodies only of *Coprinus quadrifidus*. Dung-extract agar was good only for *C. radians, C. semilantanus, Panaeolus campanulatus* and *Stropharia semiglobata.*

The following species did not form fruiting-bodies on any of the media upon which they were grown: *Coprinus atramentarius, C. comatus, C. plicatilis, Galera crispa, G. tenera, Psilocybe subviscida.*

It was observed in all of the species that produced fruiting-bodies that the most typical sporophores were the first ones that developed after the fungus was secured in culture. As the age of culture of the fungus increased, the ability to form fruiting-bodies decreased. The rate of decline of this capacity varied with the different species.

DISCUSSION AND CONCLUSIONS

The following species formed fruiting-bodies on one or more media: *Coprinus fimentarius macrorhizus, C. micaceus, C. quadrifidus, C. radians, C. radiatus, C. semilantanus, Panaeolus campanulatus, P. retirugis, P. solidipes* and *Stropharia semiglobata.*

The media that were most valuable for sporophore production were straw with water or malt-extract, modification of Etter's

medium, dung-extract agar, potato malt agar and potato glucose agar. Only a few of the 87 media tested were valuable for the production of fruiting-bodies.

Failure of poisons and "growth-promoting" substances to induce the formation of fruiting-bodies must mean that the production of fruiting-bodies depends upon more than the stimulus given by the substances as they were used in the experiment.

GENETICAL STUDIES

Materials and methods

The species that were used in this phase of the study are as follows:[3] *Anellaria separata* (Fries) Karsten, *Coprinus fimetarius macrorhizus* Fries, *C. micaceus* Fries, *C. plicatilis* Fries, *C. radians* Fries, *C. semilantanus* Peck, *Naucoria semiorbicularis* (Fries) Quél., *Panaeolus papilionaceus* (Fries) Quél., *P. retirugis* (Fries) Quél., *Psathyrella disseminata* (Fries) Quél., *Psilocybe Foenisecii* (Fries) Quél., and *P. subviscida* Peck.

The culture of *Coprinus radians* was from a fruiting-body that appeared on the campus of Northwestern University, Evanston, Illinois, in June, 1935. Monosporous cultures of certain fungi were secured from the Centraalbureau voor Schimmelcultures, Baarn, Holland: *Coprinus micaceus* from Belgium, *Panaeolus papilionaceus* from Vienna and *P. retirugis* from Paris. The other species were secured near East Lansing, Michigan.

In the pairing of the mycelia small masses of mycelium from any two cultures were placed a few millimeters apart on a potato malt agar medium in a test-tube. The resultant mycelium was examined after two to four weeks for the presence of clamp-connections.

RESULTS OF PAIRINGS

Mycelia from the same fruiting-body

The results are given in Table 1.

[3] See first footnote under "Materials and methods" of culture studies.

TABLE 1

RESULTS OF PAIRINGS OF MONOSPOROUS MYCELIA OF VARIOUS AGARICS

Species	Number of monosporous mycelia used	Results
Anellaria separata	18	Regularly quadripolar
Coprinus fimetarius macrorhizus	29	Irregularly bipolar
Coprinus micaceus		
(culture 16a)	9	No clamp-connections
(culture 127)	19	Irregularly bipolar? or irregularly quadripolar?
Coprinus plicatilis	16	Regularly quadripolar. False clamps in certain combinations
C. radians	21	No clamp-connections
C. semilanatus	14	Regularly quadripolar
Naucoria semiorbicularis		
(culture 106)	17	Regularly bipolar
(culture 112)	8	Regularly bipolar
Psathyrella disseminata	15	No clamp-connections
Psilocybe Foenisecii	9	Irregularly quadripolar
P. subviscida	17	Probably bipolar with many irregularities

Geographic races

COPRINUS MICACEUS

Nine mycelia of culture 127 and nine of culture 16a (both from East Lansing, Michigan) were paired. No clamp-connections were formed. This was not unexpected since culture 16a had changed (all nine mycelia) in color and spore type since it was first cultured.

Cultures from Belgium were paired with cultures 16a and 127. No clamp-connections were formed.

NAUCORIA SEMIORBICULARIS

Eight mycelia of culture 112 were paired in all combinations with eight mycelia of culture 106. These two cultures were collected within one and one-half miles of each other. Clamp-connections were found in all but two of the pairings.

Interspecific pairings

The results are given in Table 2.

TABLE 2

RESULTS OF PAIRINGS BETWEEN MONOSPOROUS MYCELIA OF DIFFERENT SPECIES

Cross	Number of pairings	Results
Coprinus semilantanus × *C. fimetarius macrorhizus*	32	No clamps
C. micaceus (culture 16a) × *C. fimetarius macrorhizus*	32	No clamps
C. micaceus (culture 127) × *C. fimetarius macrorhizus*	32	No clamps
C. micaceus (culture 127) × *C. plicatilis*	32	No clamps
Panaeolus papilionaceus × *P. retirugis*	4	No clamps

Intergeneric pairings

The results are given in Table 3.

TABLE 3

RESULTS OF PAIRINGS BETWEEN MONOSPOROUS MYCELIA OF DIFFERENT GENERA

Cross	Number of pairings	Results
Anellaria separata × *Panaeolus papilionaceus*	16	No clamps
A. separata × *Naucoria semiorbicularis*	24	One to three clamps found in each of four pairings
A. separata × *Panaeolus retirugis*	16	One clamp-like structure in one of the pairings
N. semiorbicularis × *P. papilionaceus*	16	No clamps
N. semiorbicularis × *P. retirugis*	12	No clamps
Coprinus plicatilis × *Psathyrella disseminata*	32	No clamps

DISCUSSION AND CONCLUSIONS

On the basis of clamp-connections, it could not be decided whether *Coprinus radians* was homothallic or heterothallic. Brunswik (**1**), on the basis of the formation of fruiting-bodies, and Chow (**2**) and Vandendries (**15**, **16**), on the basis of the distribution of clamps, concluded that the species is bipolar.

Also in the case of *Psathyrella disseminata* the absence of clamp-connections prevented determination of whether the species is homothallic or heterothallic. Vandendries (**17**), however, found,

on the basis of the distribution of clamp-connections, that the fungus was bipolar.

The results of the writer's studies indicate that the following species are bipolar: *Coprinus fimetarius macrorhizus* and *Naucoria semiorbicularis.*

The following species were found to be quadripolar: *Anellaria separata, Coprinus plicatilis, C. semilantanus* and *Psilocybe Foenisecii.*

The great number of irregularities in the formation of clamp-connections made it impossible to decide definitely whether *Coprinus micaceus* (culture 127) and *Psilocybe subviscida* were bipolar or quadripolar. The writer thinks it likely that the former was quadripolar and the latter bipolar.

Irregularities in the pairing-reaction were found in *Coprinus micaceus* (culture 127), *C. semilantanus, Psilocybe Foenisecii* and *P. subviscida.*

In no species was there evidence of barrage such as found by Vandendries and Brodie (**19**).

False clamp-connections were found only in *Coprinus plicatilis.* They developed only in those combinations that would result in a mycelium heterozygous for the factor A and its allelomorph a, and homozygous for the factor B or its allelomorph b. Such a condition was found by Quintanilha (**14**) in *Coprinus fimetarius.*

In regard to geographic races it was found that spores from two fruiting-bodies of *Naucoria semiorbicularis* collected about one and one-half miles apart were compatible in almost all combinations. In *Coprinus micaceus* no clamp-connections formed in any of the combinations of mycelia from near East Lansing, Michigan, or in the combinations of mycelia from that city with mycelia from Belgium.

No interspecific crosses were obtained. Vandendries (**15**, **18**) has obtained a few interspecific crosses.

Of the six intergeneric crosses that were attempted, clamp-connections were found very infrequently in one-sixth of the pairings of *Anellaria separata* with *Naucoria semiorbicularis.* In one of the pairings of *A. separata* with *Panaeolus retirugis* a structure that somewhat resembled a clamp-connection was found. In the other four sets of pairings of different genera no clamps were found.

The author has not found in the literature any record of an intergeneric cross in the Agaricaceae.

It seems advisable to point out that in all of the work dealing with the production of clamp-connections between different species and genera in the agarics only a small number of spores have been used. It seems to the author quite possible that many more crosses could be obtained if the workers were to use large numbers of monosporous mycelia in the pairings.

Apparently almost everyone has explained the irregularities of the pairing-reaction and the existence of geographic races as due to the mutations of the genes that influence the diploidization of mycelia. Such an explanation *may* be the best one, but the author thinks that perhaps too much emphasis has been placed upon the idea of mutations. Dickson (**3**) has suggested that the formation of abnormal sporophores of *Coprinus sphaerosporus* might be due to the presence in at least one of the mycelia of a number of recessive genes and/or such chromosome aberrations as translocations and deletions. Perhaps such a condition would explain other results obtained in the study of agarics.

ACKNOWLEDGMENT

The writer is deeply grateful to Dr. E. A. Bessey for his encouragement, advice and assistance during this study.

DEPT. OF BOTANY,
UNIV. OF MISSOURI,
COLUMBIA, MISSOURI

LITERATURE CITED

1. **Brunswik, Hermann.** Untersuchungen über die Geschlectsund Kernverhältnisse bei der Hymenomyzetengattung Coprinus. Botanische Abhandlungen **5**: 4–152. 1924.
2. **Chow, Chung Hwang.** Contribution à l'étude du développement des Coprins. Le Botaniste **26**: 89–232. 1934.
3. **Dickson, Hugh.** Studies in *Coprinus sphaerosporus*. III. The inheritance of factors affecting the growth-rate at different temperatures of certain strains. Ann. Bot. **50**: 219–246. 1936.
4. **Etter, Bessie E.** New media for developing sporophores of wood-rot fungi. Mycologia **21**: 197–203. 1929.
5. **Fries, Elias.** Systema Mycologicum **1**. 1821.
6. ——. Elenchus Fungorum. 1828.
7. ——. Epicrisis Systematis Mycologici. 1836–1838.

8. ——. Monographia Hymenomycetum Sueciae. 1857.
9. ——. Hymenomycetes Europaei. 2nd edition. 1874.
10. **Gillet, C. C.** Les Hymenomycètes. 1874.
11. **Karsten, P. A.** Rysslands, Finlands, och den Skandinaviska halföns Hattsvampar. Bidr. Finl. Nat. Folk **32:** I–XXVIII, 1–550. 1879.
12. **Kauffman, C. H.** The Agaricaceae of Michigan. Michigan Geological and Biological Survey. Publication 26. Biological Series 5. 2 volumes. Lansing. 1918.
13. **Quélet, M. L.** Les Champ. du Jura et des Vosges. 1872.
14. **Quintanilha, A.** Cytologie et génétique de la sexualité chez les Hyménomycètes. Bol. Soc. Broteriana **10:** 289–332. 1935.
15. **Vandendries, Rene.** Nouvelles recherches sur la sexualité des Basidiomycètes. Bull. Soc. Roy. Bot. Belg. **56:** 73–97. 1923.
16. ——. Contribution nouvelle à l'étude de la sexualité des Basidiomycètes. La Cellule **35:** 129–155. 1925.
17. ——. La bipolarité sexuelle chez *"Coprinus disseminatus"* Pers. Bull. Soc. Roy. Bot. Belg. **62:** 133–136. 1929.
18. ——. Les modalités sexuelles des Basidiomycètes. Ibid **70:** 66–86. 1937.
19. —— **& H. J. Brodie.** Nouvelles investigations dans le domaine de la sexualité des Basidiomycètes. La Cellule **42:** 165–210. 1933.

A NEW SPECIES OF DOTHIORA ON ASPEN AND WILLOW

C. L. Shear and Ross W. Davidson

(with 3 figures)

Several species of the genus *Dothiora* Fries are common and widely distributed, but detailed studies of their conidial stages have not been reported. The present paper describes a new species of this genus and includes the results of a study of its conidial stages in pure culture. The cultures were also compared with ascospore cultures of *Dothiora Sorbi* (Wahl.) Fuckel.

Dothiora polyspora Shear & Davidson, sp. nov.

Ascocarps innate-erumpent, depressed-pulvinate, circular or irregular in outline, densely gregarious, smooth, black; locules single or occasionally several, thick lenticular, astomous (fig. 1, *A, B*); asci polysporous (24 or more spores), cylindric-clavate, short stipitate, 90–115 × 12–15 μ, aparaphysate; spores when mature muriform with 3 transverse septa and frequently 1 or rarely 2 longitudinal septa in the upper cells, clavate, constricted in the middle, upper half broader, hyaline, 15–18 × 5–6 μ. Conidia in culture hyaline, 1-celled, 8–15 × 4–6 μ in size, borne on the mycelium as in *Dematium;* pycnidia in culture on sterilized willow twigs resemble those of the genus *Dothichiza* Lib., producing hyaline, 1-celled spores, 6–10 × 3–5 μ in size.

Ascomatibus dense aggregatis, innato-erumpentibus, pulvinatis, levibus nigris; loculis monostichis, intus pallidis, astomis; ascis tereti-clavatis, breve stipitatis, aparaphysatis, polysporis, 90–115 × 12–15 μ; sporidiis hyalinis, muriformibus, 3 septatis, medio constrictis, 15–18 × 5–6 μ.

Hab.: Branches of *Populus tremuloides aurea* (Tidestrom) Daniels and *Salix* spp., Mesa Lakes, Grand Mesa Mt., Colo., 9800 ft. elev., coll. R. W. Davidson June 18, 1930 and June 1, 1938. Type no. *4222* (F. P. 71991), on *Populus tremuloides aurea,* deposited in the Mycological collections of the Bureau of Plant Industry.

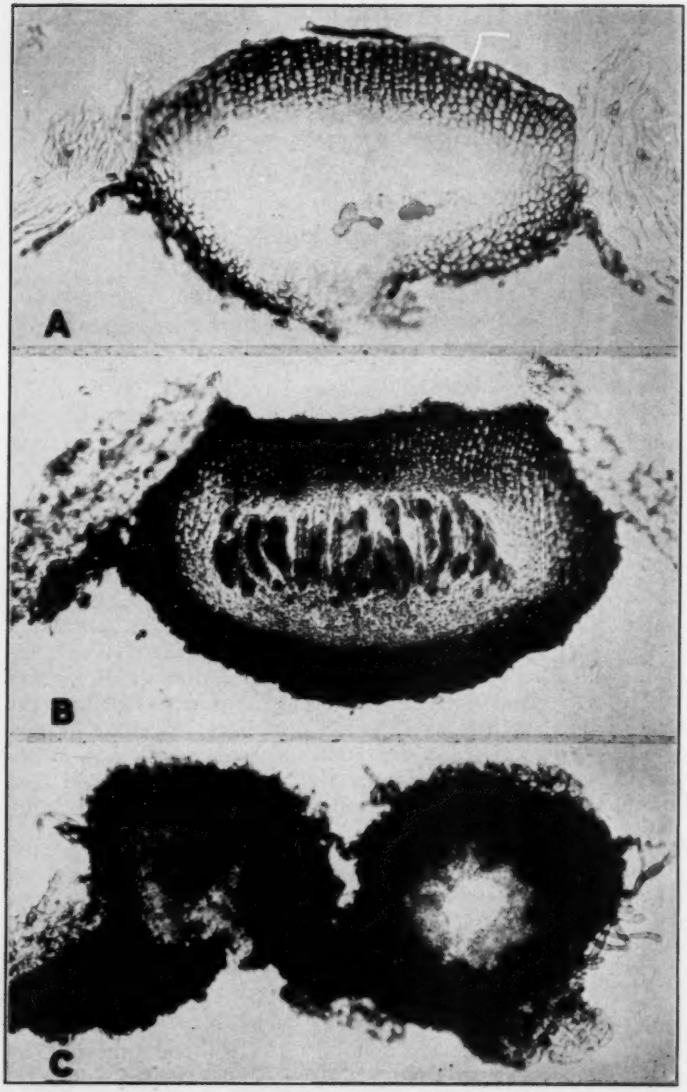


FIG. 1. *A* and *B*, sections through ascocarps of *Dothiora polyspora* showing structure. *A*, immature ascocarp; *B*, mature ascocarp; *C*, section through pycnidia of *D. polyspora* developed in culture on sterilized willow twigs.

Dothiora polyspora differs from *D. sphaeroides* (Pers.) Fries (**3**) and *D. Salicis* Vleugel (**6**), the two species already described on *Populus* and *Salix*, in its polysporous asci and smaller ascospores. It is, of course, possible that *D. polyspora* is a polysporous form or variety of *D. Salicis*, as the spores average approximately one-half the size of those in that species. The number of spores, however, is consistently greater than 16 in all the material collected in 1930 and 1938 with the normal number probably being 32. Heretofore species with polysporous asci have generally been placed in separate genera, but unless there are other distinct differences we do not think they should be separated. As already suggested polysporous forms may be only varieties of common 8-spored species.

HOST RELATIONSHIP

The presence of *Dothiora polyspora* on dead tips of living twigs of aspen and willow and on stem cankers of young aspen (FIG. 2, *A–D*) suggests that it may be a weak parasite, but a test of its parasitism by inoculation with pure cultures has not been attempted. Since it was collected only at a high elevation it seems possible that frost injury may predispose the hosts to infection. The stem cankers were typically annual.

Most of the specimens were collected on an open rocky area near Sunset Lake at the Mesa Lakes resort. Snow was still several feet deep in places on the area and the leaf buds had not begun to open on June 1. Most of the aspen was small and scrubby and apparently received little protection from larger trees.

CONIDIAL STAGES IN CULTURE

Ascospores of *Dothiora polyspora* placed on agar medium (Difco-corn-meal agar, at 11° C.) swelled noticeably during the first 24 hours and some of the swollen cells had germinated (FIG. 3, *A, B*). Single asci containing mature spores had numerous germ tubes growing out through the ascus wall. Growth thereafter continued very slowly, but hyaline 1-celled conidia which had apparently budded off of the young hyphae were present in the cultures at the end of the second day (FIG. 3, *C*). Except for the extremely slow growth, about 15 mm. in diameter in 2 weeks, the

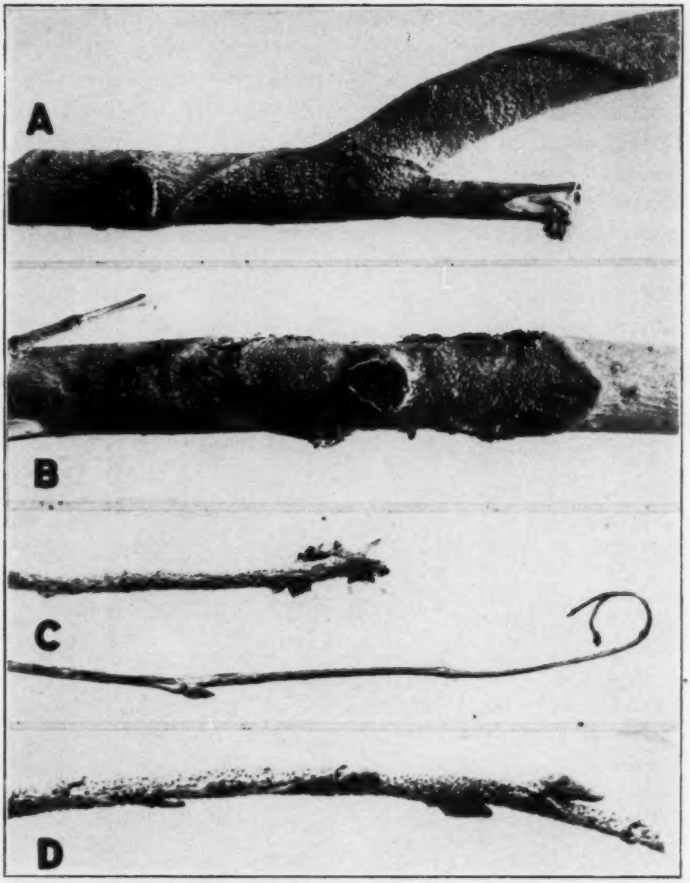


FIG. 2. *Dothiora polyspora* on aspen and willow. All show the densely aggregated fruiting pustules. *A* and *B*, cankers on aspen stems; *C*, fruiting on dead tips of aspen twigs; *D*, same on willow twig. Photographs by M. L. F. Foubert.

cultures were similar to cultures of fungi belonging to the form genus *Dematium*. On corn-meal or malt agar the hyphae are mostly short, crooked and multi-septate, being composed largely of swollen, somewhat rounded, light to dark brown cells. The conidia bud off from the irregular hyphal cells and are variable in size

from 8–15 × 4–6 μ. Ascospores incubated at a room temperature of about 28° C. failed to grow.

Single-ascospore cultures of *Dothiora polyspora* were compared with single-ascospore cultures of *Dothiora Sorbi*, an 8-spored species, and it was found that their conidial stages were very similar. The ascospores of *D. Sorbi* swell greatly during the first day and continue to enlarge mostly by cell division, rather than by elongation of germ tubes, during the second and third days (FIG. 3, *E*, *F*). Only a few short hyphae were seen at the margin of the rounded, mound-like, cellular mass. Hyaline conidia budded off from these mound-like growths during the second day of incubation (FIG. 3, *G*). Later the cultures became dark and developed more nearly normal hyphae. Brefeld (**1**) recorded similar observations for *D. Sorbi* ascospores, but he obtained no mycelial development as he did with *Sphaerulina intermixta* (Berk. & Br.) Sacc. and *Dothidea* (?) *polyspora* Brefeld, two other species with *Dematium*-like conidial stages, which he studied in culture.

Steam-sterilized willow twigs were inoculated with single-ascospore cultures of *Dothiora polyspora*. Some of them were incubated in a refrigerator at 11° C., and others were incubated at a temperature of about 25° C. for a period of several months. Some of the twigs held at 25° C. developed small globular pycnidia on their surface and from these hyaline 1-celled spores (6–10 × 3–5 μ in size) were extruded in long, delicate, ribbon-like, white cirrhi. Twigs held at 11° C. developed numerous similar small globular masses but none was found to contain spores.

Sections through the pycnidia developed on the willow twigs disclosed an irregular cavity containing numerous 1-celled, hyaline spores but no conidiophores. The walls were thick, irregular, and with no definite structural arrangement (FIG. 1, *C*). No ostioles were seen. In structure and development the pycnidia in pure culture were more nearly like those of the form genus *Dothichiza* Lib. (**4**). Macroscopically the pycnidia appeared to have developed on the surface of the twigs, but sections showed them to be erumpent through the outer bark.

PYCNIDIA IN NATURE

Several pycnidial forms were present on some of the willow twigs on which *Dothiora* was fruiting, but none of these was definitely proved to be the pycnidial stage of *D. polyspora*. The pycnidial stage which is thought to be a form of this ascomycete was previously referred to *Dothichiza* sp. (2). The host relationship of this *Dothichiza* and its macroscopic appearance, especially its dense aggregation of pycnidia on dying tips of twigs, are similar to those of *Dothiora polyspora* (FIG. 2, *D*). The pycnidia are erumpent through the epidermis. At first the stroma is delicate

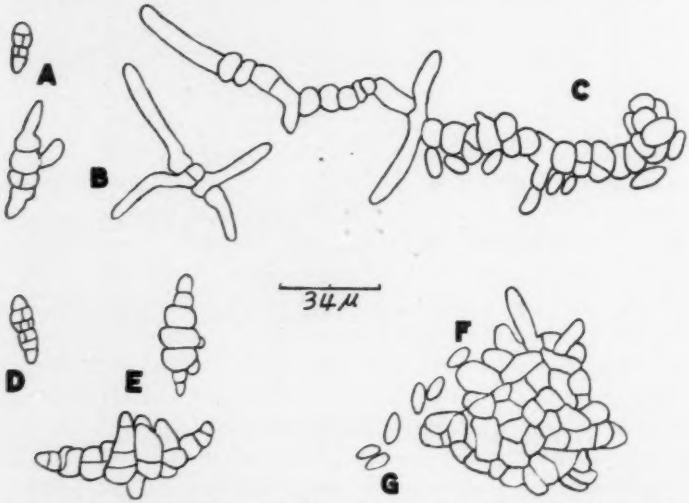


FIG. 3. *A–C, Dothiora polyspora. A,* ascospore; *B,* germinating ascospores after one day on corn-meal agar; *C,* two-day growth, showing conidia around hypha. *D–G, Dothiora Sorbi. D,* ascospore; *E,* germinating ascospores after one day on corn-meal agar; *F,* germinating ascospore after two-day development; *G,* conidia.

and inconspicuous with the conidia developing just underneath the epidermis on a somewhat heavier basal aggregate of fungus tissue, which apparently gradually develops into a heavier dark sclerotoid mass of fungus cells. This heavy stroma-like structure appears to be an ascocarpic primordium.

This *Dothichiza* form collected on willow twigs at Grand Mesa in 1930 is somewhat similar to *D. tremulae* (Sacc.) Hoehn., which was first described by Saccardo (**5**) as *Phoma tremulae,* but it is not the same species. It is interesting to note that von Hoehnel referred *P. tremulae* to *Dothichiza* (**4**) and implied that it is most certainly a stage of *Dothiora.* If, as von Hoehnel suggested, species of *Dothichiza* of this type are usually imperfect stages of *Dothiora* it is reasonable to expect the *Dothichiza* sp. from Colorado to be an imperfect stage of *Dothiora polyspora.*

BUREAU OF PLANT INDUSTRY
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

LITERATURE CITED

1. **Brefeld, O.** Untersuchungen aus dem gesammtgebiete der Mykologie Heft X, Ascomyceten II. *276. pl. 10, f. 8–12.* 1891.
2. **Davidson, R. W.** Fungi from Grand Mesa National Forest, Colo. Plant Disease Reporter **15:** 75–82. 1931.
2. **Fries, E.** Summa. Veg. Scand. 419. 1849.
4. **Hoehnel, F. v.** Uber den Spermatienpilz von *Dothiora xylostei* Fuckel. Frag. Myk. No. *968.* 1916.
5. **Saccardo** in Sydow. Myc. Germ. Fasc. V–VI. Ann. Myc. **2:** 529. 1904.
6. **Vleugel, J.** Bidrag till Kännedomen om Umeåtraktens Svampflora. Sv. Bot. Tidskr. **2:** 374. 1908.

THREE PEZICULA SPECIES OCCURRING ON ALNUS [1]

J. WALTON GROVES [2]

(WITH 12 FIGURES)

The occurrence of species of the genus *Pezicula* on *Alnus* appears to have almost entirely escaped notice in North American literature with the exception of *Dermatea Alni* Rehm, reported by Povah (**1935**) from Michigan. Early records of *Patellaria rhabarbarina* Berk. on this host by Curtis (**1867**) and Peck (**1869**) are probably based on a *Pezicula,* but no description was given. The true *P. rhabarbarina* is a *Pezicula* occurring on *Rosa* and it is improbable that the fungi collected on *Alnus* belonged to this species.

In the Temagami Forest Reserve, Ontario, three well-defined species of *Pezicula* occur on this host. In this region two species of *Alnus* are found, *A. incana* (L.) Moench. and *A. crispa* var. *mollis* Fernald, and the fungi show a certain amount of host specialization. *Pezicula aurantiaca* Rehm has been collected only on *A. crispa* var. *mollis, P. Alni* Rehm chiefly on *A. crispa* var. *mollis,* but occasionally on *A. incana,* and the third species, which appears to be undescribed, has been found only on *A. incana* with one collection on *Betula lutea.*

These three species were cultured from both ascospores and conidia and the cultures were grown on two per cent malt extract agar and on sterilized twigs of the host. The twig cultures were prepared as described in an earlier paper (Groves **1936**). The cultures from ascospores and conidia were similar and both re-

[1] Contribution No. *596* from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada. Part of the work was done at the Department of Botany, University of Toronto, and was included in a thesis presented to the School of Graduate Studies of that University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2] Graduate Assistant, Central Laboratory, Ottawa.

turned the same type of conidial stage in culture but no apothecia were developed. The appearance of the cultures of each of the three species was distinctive, and each could readily be distinguished by means of the conidia. The following descriptions are based on the material used in these studies.

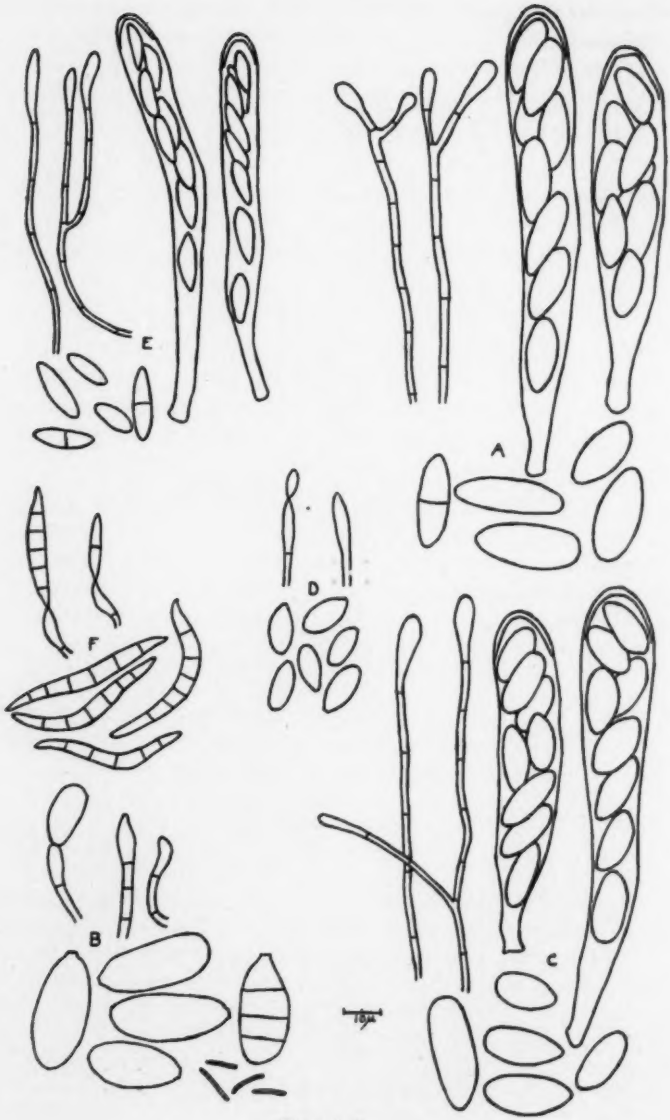
PEZICULA AURANTIACA Rehm, Ber. Bayer. Bot. Ges. **13**: 198. 1912.

Habrostictis aurantiaca Rehm, 26 Ber. Nat. Ver. Augsburg **26**: 67. 1881.

Ocellaria aurantiaca Rehm, Rab. Krypt.-Fl. 1^3: 135. 1889.

Apothecia erumpent to subimmersed, scattered, separate, occasionally two or three in a cluster, circular or somewhat irregular, sessile, scarcely narrowed below, 1–2 mm. in diameter, 0.3–0.5 mm. in height, waxy in consistency, more fleshy when moist; hymenium concave to plane or slightly convex, slightly pruinose, "buffy brown," "light brownish olive," "tawny olive," much brighter when moist, close to "ochraceous orange," sometimes deciduous, margin at first thick, brighter than hymenium and conspicuous, later sometimes disappearing; tissue of the hypothecium compact, pseudoparenchymatous, composed of hyaline or pale-yellowish almost isodiametric to more or less elongated cells about 5–12 μ in diameter, and with the walls grown together, arranged in more or less vertically parallel rows, curving obliquely toward the outside; subhymenium a narrow zone composed of slender, interwoven hyphae; asci cylindric-clavate, short-stalked, 8-spored, (80)–100–125–(140) $\times$ 15–20 μ; ascospores oblong-ellipsoid to ovoid, hyaline, straight or sometimes slightly curved, one celled, occasionally 2–4 celled, irregularly biseriate to crowded, 18–32 $\times$ 8–12 μ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.0 μ in diameter, widened at the tips to about 5 μ and forming a slight epithecium.

The conidial fruiting bodies are inconspicuous, developing beneath the outer bark layers and raising and splitting them, but scarcely breaking through, the spores emerging through the cracks in the bark in whitish masses. The stromata are circular to slightly elongated, 0.4–1.2 mm. in diameter, obtusely conical to cushion-shaped or discoid, up to 0.5 mm. in thickness in the central part, waxy when dry, more fleshy when moist; the tissue composed of closely interwoven, ascending hyphae, about 3–5 μ in diameter, forming a more or less indefinite but slightly more compact zone below the fruiting surface; conidiophores borne more or less ex-



FIGS. 1–3.

posed over the upper surface or in widely opening cavities, hyaline, cylindric to sub-clavate, simple, occasionally branched, continuous or septate, very variable in length, 15–25–(65) × 3–5 μ, and sometimes swollen below the point of attachment of the spore up to 7 μ; conidia oblong-ellipsoid, to ovoid, hyaline, one-celled, occasionally 2–4-celled, straight or slightly curved, ends rounded, one end with a truncate apiculus, 25–40 × 12–16 μ; microconidia not observed in nature but in culture are hyaline, filiform, straight or curved, one-celled, 6–14 × 1.5–2.0 μ.

HOST: *Alnus crispa* var. *mollis* Fernald.

TYPE: Rehm: Ascomyceten *266*.

EXSICCATI: Rehm: Ascomyceten *266*.

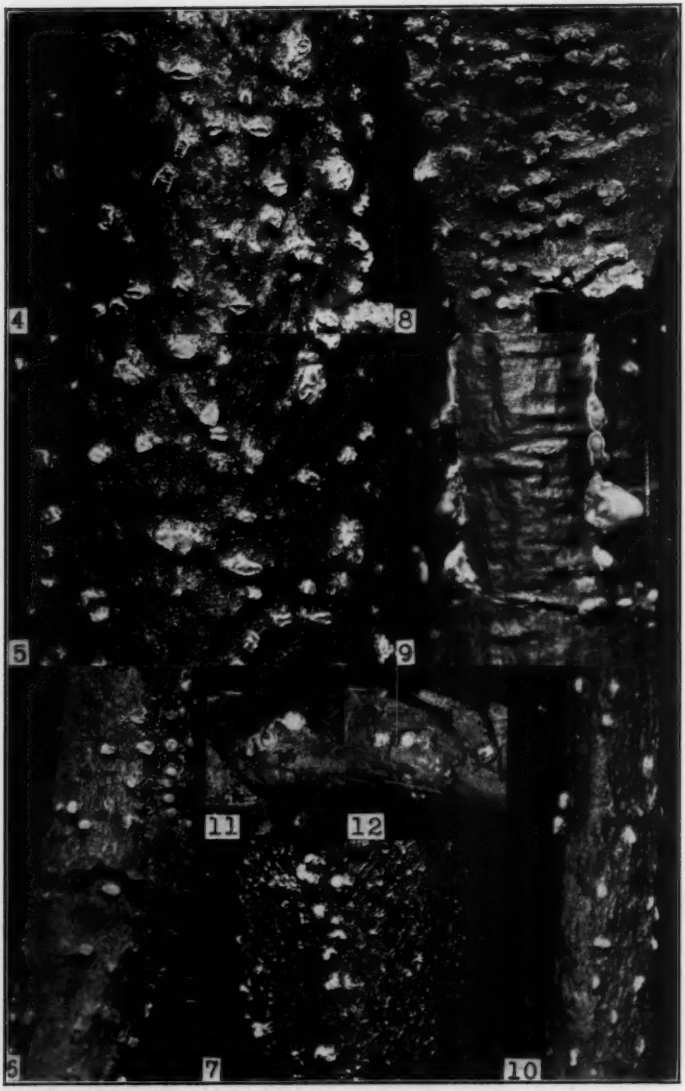
SPECIMENS EXAMINED: University of Toronto Herbarium. On *Alnus crispa* var. *mollis*. *8434* (*407*),[3] *8405* (*426*), Temagami Forest Reserve, Ontario. Durand Herbarium. *7519*. A fragment of Rehm: Ascomyceten *266*. Herbarium of J. W. Groves. On *Alnus crispa* var. *mollis*. *418, 483,* Temagami Forest Reserve, Ontario.

On malt extract agar the colonies reach a diameter of about 4 cm. in three weeks. They are whitish at the margin, becoming more or less zoned and variously coloured toward the centre, "sea foam green," "sea foam yellow," "honey yellow," to "yellowish citrine," with downy to velvety aerial mycelium, sometimes with white, cottony tufts. The tissue is composed of interwoven hyphae as in nature, but is looser, and the walls of the hyphae are more distinct. The conidia are produced in irregularly lobed cavities which tear open widely, exposing the whitish spore masses. The conidia and conidiophores are typical and microconidia are present.

On twigs of *Alnus crispa* var. *mollis* and *A. incana* this species grows equally well in culture. Usually a whitish to buff or brownish, cottony tuft of aerial mycelium develops at the point of inoculation, but does not spread over the twig. The conidial stromata

[3] The numbers in brackets refer to duplicate specimens in J. W. Groves' herbarium.

FIGS. 1–3. 1, *Pezicula aurantiaca*, *A*, asci, ascospores, and paraphyses, *B*, conidiophores, conidia and microconidia; 2, *P. Alni*, *C*, asci, ascospores, and paraphyses, *D*, conidiophores and conidia; 3, *P. alnicola*, *E*, asci, ascospores, and paraphyses, *F*, conidiophores and conidia.



FIGS. 4–12.

are erumpent, breaking through the bark and developing on the surface, usually separate, scattered, downy to tomentose, whitish to buff or cinnamon, almost globose, 0.3–2.0 mm. in diameter, containing one or more globose to irregularly lobed cavities. The tissue is sometimes pseudoparenchymatous at the base, but mostly composed of interwoven hyphae with a compact zone surrounding the cavity, and a loose weft of hyphae at the outside. The conidiophores and conidia are typical and microconidia are produced.

Pezicula aurantiaca can be readily distinguished from the other two species by its gross appearance. The apothecia are of a different colour and much larger than in the other species, and have a characteristic immersed habit of growth becoming more strongly erumpent when moist. In this respect, *P. aurantiaca* is similar to the common *Ocellaria ocellata* (Pers.) Schroet. occurring on *Salix* and *Populus*. When a series of species including *O. ocellata, P. aurantiaca,* and *P. Corni* Petr. are considered, it is found impossible to draw a clear cut generic distinction between *Ocellaria* and *Pezicula.*

The conidial fruiting bodies could be referred to the form genus *Cryptosporiopsis.* The conidia are of the typical oblong-ellipsoid form, usually found in the imperfect stages of *Pezicula* species. They can be distinguished from the conidia of *P. Alni* by their larger size and more oblong shape.

PEZICULA ALNI Rehm, Ber. Bayer. Bot. Ges. **13**: 199. 1912.

Pezicula quercina f. *Alni* Fuckel, Symb. Myc. Nachtr. **2**: 56. 1874.

Dermatella quercina var. *Alni* Sacc. Syll. Fung. **8**: 490. 1889.

Dermatea Alni Rehm, Rab. Krypt.-Fl. 1^3: 252. 1889.

Apothecia erumpent, scattered, mostly separate, occasionally with two or three in a cluster, circular to slightly elongated, sessile,

FIGS. 4–12. 4, apothecia of *Pezicula aurantiaca* in dried condition; 5, apothecia of *P. aurantiaca* moistened; 6, apothecia of *P. Alni;* 7, conidial stage of *P. Alni* on a twig in culture; 8, apothecia of *P. alnicola;* 9, conidial stage of *P. alnicola* on a twig in culture; 10, conidial stage of *P. aurantiaca* in nature; 11, conidial stage of *P. aurantiaca* in nature with a portion of the outer bark removed to show the fruiting bodies; 12, conidial stage of *P. alnicola* in nature with a portion of the outer bark removed to show the fruiting bodies. All × 4 approx.

slightly narrowed below, 0.3–0.8–(1.0) mm. in diameter and 0.5 mm. or less in height, brittle, waxy in consistency, softer and more fleshy when moist; hymenium plane to convex, slightly pruinose, at first with a slightly paler margin which soon disappears, brownish-ochraceous, brighter when moist, "cinnamon buff" to "ochraceous-buff," sometimes close to "deep colonial buff," excipulum concolorous becoming darker toward base; tissue of the basal stroma compact, pseudoparenchymatous, composed of irregular cells 3–8 μ in diameter, the walls dark coloured and grown together, the hypothecium composed of more or less vertically parallel, colourless, hyphae, curving obliquely toward the outside and forming a darker, pseudoparenchymatous, excipulum two to three cells in thickness; subhymenium indefinite, asci clavate, broad, four- or eight-spored, mostly eight-spored, (85)–100–120–(130) $\times$ (13)–15–18–(20) μ; ascospores oblong-ellipsoid, hyaline, straight, one-celled, occasionally 2–4-celled, irregularly biseriate, (12)–15–20–(25) $\times$ (5)–7.5–10 μ; paraphyses hyaline, filiform, septate, usually branched, 2.0–2.5 μ in diameter, the tips swollen up to 7–8 μ, clavate to subglobose, forming a slight epithecium.

The conidial fruiting bodies are extremely inconspicuous, developing beneath the outer bark layers and splitting them, but scarcely breaking through, the conidia emerging in whitish masses. The stroma is slightly conical to cushion-shaped or flattened, about 0.4–0.6 mm. in diameter and 0.3 mm. in thickness at the centre, blackish, waxy when dry, more fleshy when moist, the tissue similar to the basal stroma of the apothecia; conidiophores hyaline, cylindric to clavate, simple or occasionally branched, continuous or sometimes septate, 12–30 $\times$ 2.5–4 μ, borne over the outer surface of the stroma, conidia ovoid to oblong-ellipsoid or sub-fusiform, hyaline, one-celled, one end with a small, truncate apiculus, (12)–14–18–(20) $\times$ 5–7.5 μ. Microconidia not observed.

HOST: *Alnus crispa* var. *mollis* Fernald, *A. incana* (L.) Moench., *Alnus* spp.

TYPE: Rehm: Ascomyceten *463*.

EXSICCATI: Rehm: Ascomyceten *463*; Krieger, Fungi Sax. *1625*.

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Alnus crispa* var. *mollis*. *6110* (*159*), *8406* (*414*), Temagami Forest Reserve, Ont. On *A. incana*. *8407* (*417*), Temagami Forest Reserve, Ont. On *Alnus* sp. Ex herbarium University of Michigan, F. P. *731*, Isle Royale, Mich. Durand Herbarium. *6338*. On *Alnus* sp. Rav. Fungi Car. **5**: *46* (as *Patellaria rha-*

barbarina). Farlow Herbarium. Ex. Herb. Barbey-Boissier. *1122*. Coll. Fuckel. Herbarium of J. W. Groves. On *Alnus crispa* var. *mollis 452,* Temagami Forest Reserve, Ont. *496, 556,* Glenmont, Nova Scotia. On *Alnus* sp. *515,* Portapique, Colch. Co., Nova Scotia, L. E. Wehmeyer (*1602*).

On malt extract agar the colonies grow slowly reaching a diameter of about 2 cm. in three weeks. They have a narrow, whitish margin, shading abruptly to olive-gray, and becoming dark-gray to olivaceous-black with short, velvety-cottony, aerial mycelium, sometimes forming gray to whitish tufts. The conidial stromata are usually produced abundantly, 0.5–1.0 mm. in diameter, olive-gray to whitish, almost globose, downy-tomentose, tissue composed of rather loosely interwoven, brownish hyphae, 3–4 μ in diameter; conidiophores very variable in length, longer than in nature, septate, and much branched, intermingled with branching, hyphal threads about 1.5 μ in diameter; conidia typical.

On twigs of *Alnus* the aerial mycelium is fairly abundant, forming a whitish to olive-gray, cottony, cushion-like tuft at the point of inoculation and spreading more or less over the twig. The conidial fruiting bodies are erumpent, scattered, globose to cylindric, whitish to olive-gray, downy-tomentose, mostly 0.5–1.5 mm. in diameter and 0.5–1.0 mm. in height, containing one or more rounded or irregularly lobed cavities, and splitting open at the top or sides. The tissue is pseudoparenchymatous at the base, composed of dark, irregular cells, the cells becoming more elongated and arranged more or less vertically above, finally prosenchymatous around the cavities; conidiophores and conidia typical.

Pezicula Alni and the following species are fairly similar in gross appearance, although *P. Alni* is usually less caespitose, slightly darker coloured and slightly larger. In the apothecial stages they can be separated most readily by the width of the asci and spores which are both broader in *P. Alni.* They also differ in the tissue structure of the apothecia and in the appearance of the cultures, but the most striking difference is to be found in the conidial stages where the conidia in the one species are ovoid-ellipsoid and in the other are elongated to subfiliform.

There has been some slight confusion in the nomenclature of *P.*

Alni and it was necessary to decide to which of these fungi this name should apply. Fuckel (**1874**) reported a fungus on *Alnus* which he believed to be identical with his *Pezicula quercina,* but he gave no description and cited no specimen.

Rehm (**1889**) published a full description based on the specimen in Rehm: Ascomyceten *463* under the name *Dermatea Alni* (Fuckel) Rehm.

Saccardo (**1889**) proposed the combination *Dermatella quercina* var. *Alni* (Fuckel) Sacc., and added a short description, based also on Rehm: Ascomyceten *463.*

Finally, Rehm (**1912**) transferred the fungus to *Pezicula,* and stated that a Fuckel specimen in Herbier Barbey-Boissier was identical. In this account he also cited the specimen in Krieger Fungi Sax. *1625.*

It is evident then that for nomenclatural purposes we must disregard Fuckel's reference and consider Rehm as the author of the species and Rehm: Ascomyceten *463* as the type. The writer has examined Rehm: Ascomyceten *463,* Krieger, Fungi Sax. *1625,* and a Fuckel specimen in the Farlow Herbarium from Herbier Barbey-Boissier, which may be the same collection that Rehm examined. These specimens, together with the ascus and spore measurements in Rehm's description leave no doubt that his conception of *P. Alni* applies to the broad-spored species.

Pezicula alnicola sp. nov.

Pezicula Alni Niessl. in herb.

Apotheciis erumpentibus, dispersis, caespitosis, raro solitariis, orbicularibus vel mutua pressione distortis, sessilibus, 0.2–0.5–(1.0) mm. diam., 0.5 mm. altis, in sicco ceraceis, in humido carnosis; hymenio concavo vel plano, alutaceo-cinnamomeo, leviter pruinoso, margine primum pallide dein evanescente; hypothecio prosenchymato; ascis cylindricis vel cylindraceo-clavatis, breve stipitatis, octosporis, 70–110 × 8–12–(14) μ; ascosporis elliptico-fusiformibus, hyalinis, continuis vel triseptatis, rectis vel leviter curvatis, irregulariter biseriatis vel uniseriatis, (12)–15–20–(25) × 3.5–5.0–(7.0) μ; paraphysibus hyalinis, filiformibus, septatis, simplicibus vel ramosis, 1.5–2.0 μ diam., apice ad 5 μ incrassatis, leve epithecium formantibus.

Apothecia erumpent, scattered, mostly in clusters of 5–10 or more, sometimes single, circular or irregular from crowding, sessile, narrowed below, 0.2–0.5–(1.0) mm. in diameter, 0.5 mm. or less in height, brittle, waxy when dry, more fleshy when

moist; hymenium concave to plane or slightly convex, "light pinkish cinnamon" to "cinnamon" or "warm buff," slightly pruinose, at first with a delicate, paler, slightly raised margin which later may disappear; tissue of the hypothecium composed of interwoven, ascending hyphae, 3–8 μ in diameter and with the walls more or less gelatinized and grown together, sometimes looser above; asci cylindric to cylindric-clavate, short stalked, eight-spored, 70–110 $\times$ 8–12–(14) μ; ascospores ellipsoid-fusiform, hyaline, one- to four-celled, straight or slightly curved, irregularly biseriate to uniseriate, (12)–15–20–(25) $\times$ 3.5–5.0–(7.0) μ; paraphyses hyaline, filiform, septate, simple or branched, about 1.5–2.0 μ in diameter, swollen at the tips up to 5 μ and forming a slight epithecium.

The conidial fruiting bodies are very small and inconspicuous, developing beneath the outer bark layers and splitting them, but scarcely breaking through, the spores emerging in whitish masses. The stromata are usually circular, about 0.3–0.6 mm. in diameter, slightly conical to cushion-shaped, up to 300 μ in thickness at the centre, composed of interwoven, ascending, hyaline to yellowish, indistinct hyphae; conidiophores borne exposed on the upper surface or in widely opening cavities, hyaline, cylindric, pointed, continuous or septate, not branched, 10–30 $\times$ 1.5–2.5 μ; conidia elongate-fusiform to subfiliform, hyaline, 5–7 septate, almost straight, sickle-shaped, or sigmoid, ends pointed, 35–53 $\times$ 4–5 μ; microconidia not observed.

HOST: On twigs and branches of *Alnus incana* (L.) Moench. and *Betula lutea* Michx.

TYPE: University of Toronto Herbarium. *8414,* Temagami Forest Reserve, Ontario. Aug. 31, 1935.

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Alnus incana. 7396* (*253*), *7970* (*318*), *8414* (*416*), Temagami Forest Reserve, Ontario. On *Betula lutea. 8400* (*325*), Temagami Forest Reserve, Ontario. Durand Herbarium. On *Alnus glutinosa. 6879* Europe (as *Pezicula Alni* Niessl.). Herbarium of J. W. Groves. On *Alnus incana. 117, 125, 127,* Ottawa, Ontario—*250, 485,* Temagami Forest Reserve, Ontario—*598,* Camp Mercier, Laurentide National Park, Quebec.

On malt extract agar the colonies reach a diameter of 2.5–3.0 cm. in four weeks. They are almost white to various shades of gray,

often with sectors of slightly different shades of colour and rates of growth, sometimes radially furrowed and concentrically zoned, the aerial mycelium short, downy to velvety. The conidial fruiting bodies develop as rounded, more or less globose to elongated, downy, grayish stromata, up to 2–3 mm. in diameter, sometimes confluent and larger, containing a large, rounded or somewhat chambered cavity, tearing open widely; tissue of the stroma composed of closely interwoven, hyaline to yellowish hyphae about 3–5 μ in diameter, at the outside growing out into loose or somewhat tufted, hyaline, slender hyphae about 1.0–1.5 μ in diameter; conidiophores and conidia typical, the conidiophores sometimes longer than in nature.

On twigs of *Alnus* scarcely any aerial mycelium is produced. The conidial fruiting bodies are erumpent, mostly about 1.0 mm. or slightly more in diameter and about 0.5 mm. in height. They break through the bark and develop mostly on the surface as rounded, circular to elongated, grayish, downy stromata; the tissue composed of closely interwoven, hyaline to yellowish, indistinct hyphae, about 3–5 μ in diameter, the walls more or less gelatinized and grown together, containing a more or less circular to slightly lobed cavity and tearing open widely. The conidiophores and conidia are typical.

It was thought at first that this species might be *Pezicula citrinella* Rehm, also described on *Alnus,* but examination of a specimen in Rehm: Ascomyceten *262,*[4] on which the original description was based, has shown this to be a different fungus.

Pezicula alnicola is of special interest because of the unusual type of conidial stage and again illustrates the difficulty of drawing clear-cut generic lines in this group. Groves (**1939**) described several types of conidial stages belonging to species of the genus *Pezicula* and noted that although the form of the conidial fruiting body may vary considerably in this genus, the form of the conidial spore remains relatively constant and is typically oblong-ellipsoid. In the related genus *Dermatea* the conidia are typically elongate-

[4] The specimen examined was the one in the Farlow Herbarium, Harvard University. At the writer's request, Mr. E. W. Mason of the Imperial Mycological Institute, compared material of *Pezicula alnicola* with the specimen of Rehm: Ascom. *262* in the Kew Herbarium and found it to be different. This assistance is gratefully acknowledged.

fusiform to sub-filiform, but an exception was noted by Groves (**1938**) in *Dermatea acerina* (Peck) Rehm which has apothecia like a *Dermatea,* but oblong-ellipsoid conidia. In *P. alnicola* we have a species with apothecia like a *Pezicula* but elongate-fusiform to sub-filiform conidia.

The question might be raised here, as with *D. acerina,* whether it might not be desirable to erect a new genus for *P. alnicola,* but since it can be readily referred to *Pezicula* on the basis of the colour and consistency of the apothecia and general habit of growth, it is considered preferable to place it in an established genus until the relationships within the whole group are better understood.

ACKNOWLEDGMENTS

The writer is indebted to Professor H. S. Jackson, Department of Botany, University of Toronto, for his continued interest and constructive suggestions.

CENTRAL EXPERIMENTAL FARM
OTTAWA, CANADA

LITERATURE CITED

Curtis, M. A. Geological and natural history survey of North Carolina. Part III. Botany: containing a catalogue of the indigenous and naturalized plants of the state. 1–156 pp. Raleigh. 1867.

Fuckel, L. Symbolae mycologicae, Nachtr. II. Jahrb. Nass. Ver. Naturk. **27–28:** 1–99. 1873–74.

Groves, J. Walton. *Ascocalyx Abietis* and *Bothrodiscus pinicola.* Mycologia **28:** 451–462. 1936.

——. *Dermatea acerina* and *Pezicula acericola.* Mycologia **30:** 416–430. 1938.

——. Some *Pezicula* species and their conidial stages. Canadian Jour. Res. **17:** 125–143. 1939.

Peck, C. H. Ann. Rep. N. Y. State Mus. **22:** 25–106. 1869.

Povah, A. H. W. The Fungi of Isle Royale, Lake Superior. Papers Mich. Acad. Sci. **20:** 113–156. 1935.

Rehm, H. Ascomyceten: Hysteriaceen und Discomyceten. In Rab. Krypt.-Fl. 1^3: 209–336. 1889.

——. Zur Kenntnis der Discomyceten Deutschlands, Deutsch-Osterreichs und der Schweiz. Ber. Bayer. Bot. Ges. **13:** 102–206. 1912.

Saccardo, P. A. Syll. Fung. **8:** 1–1143. 1889.

SCLEROTINIA BIFRONS

H. H. Whetzel

The apothecial stage of *Sclerotium bifrons* Ellis & Ev. appears not to have been reported and described heretofore, although the sclerotial stage has been known to mycologists since 1890 when Ellis distributed it as *No. 2554* in his North American Fungi. Plant pathologists and foresters know the sclerotial stage as a frequently serious leaf pathogene of *Populus tremuloides* in North America.

The first collection of the apothecial stage of this fungus known to the writer is one made by him on April 26, 1921, near McLean, N. Y. This collection was at that time deposited in the herbarium of the Department of Plant Pathology at Cornell University, *No. 11514,* under the name *Sclerotinia bifrons* (Ellis & Ev.) Whetzel. Duplicate material of this collection under this same name was deposited shortly thereafter in the mycological herbarium of the New York Botanical Garden and in that of the University of Wisconsin.

Nearly every spring since 1921, the writer or his students have collected the apothecial stage in abundance in certain localities near Ithaca, N. Y. Critical studies on the material thus available have repeatedly been made so that the writer is thoroughly familiar with the habits and morphology of this fungus in all its stages.

On July 29, 1929, Seaver and Shope [1] collected abundant material of the apothecial stage of a sclerotial fungus in Colorado at an elevation of 9,600 feet, in a moist ravine under trees of *Populus tremuloides.* These trees at that time showed general leaf infection and maturing sclerotia of *Sclerotium bifrons.* The collectors at once assumed that they had discovered the apothecial stage of *Sclerotium bifrons* and reported their find under the name *Sclerotinia bifrons.* This is apparently the first published use of this combination.

[1] Seaver, F. J. & Shope, P. F. Mycologia **22**: 1–8. 1930.

Seaver and Shope make the remark (p. 3–4) that "Whether infection takes place directly from the germinating ascospores has not been determined but since the sclerotia and apothecia occur at about the same time, it is likely that it does." In fact the apothecia mature and disappear long before the new crop of sclerotia appear in the lesions on the trees. Our records show that apothecia mature and discharge their spores over a period of ten days to two weeks during the time when the leaf buds of the *Populus* are bursting and the young leaves are unfolding. About Ithaca, N. Y., this is during late April or May, depending on the season. Although inoculation usually occurs while the leaves are young and developing, lesions do not appear until these leaves are nearly or quite full grown. Mature sclerotia appear after some time in these lesions. Collection dates for specimens of the sclerotial stage throughout North America range from late June to early August.

To one familiar with the apothecia of *Sclerotinia bifrons* it is at once obvious even from their very brief descriptive remarks and from their excellent photographs that the apothecia which Seaver and Shope collected are not those of *Sclerotium bifrons*. This the writer has been able to fully confirm by a critical study of excellent material of the Colorado fungus kindly given him by Dr. Seaver.

A strict application of the rules of nomenclature in this case would apparently require that the combination *Sclerotinia bifrons* be used for the fungus, the apothecial stage of which is described and figured by Seaver and Shope. Since, however, there is here clearly involved an error in identification on their part, and since the species name is already universally associated with the common sclerotial fungus on *Populus*, both common sense and sound scientific practice would seem to sanction the application of the name *Sclerotinia bifrons* to the fungus heretofore known as *Sclerotium bifrons* Ellis & Ev., giving to the fungus of Seaver and Shope another name.

The combination *Sclerotinia bifrons* Seaver and Shope has also unfortunately appeared in print in a recently published textbook.[2] That there may be no further confusion regarding the proper application of the name *Sclerotinia bifrons*, a brief technical descrip-

[2] Boyce, J. S., Forest Pathology, p. 144. 1938. Hubert in his Outline of Forest Pathology, p. 215, 1931, also uses this combination but erroneously attributes it to Ellis and Everhart.

tion of the apothecial stage of *Sclerotium bifrons* Ellis & Ev. is here presented.

Sclerotinia bifrons Whetzel, sp. nov.

Apotheciis singulis, raro duobus vel tribus, margine cujusque sclerotii, 2–10 mm. diam., ample infundibuliformibus dein patelliformibus, 'Saccardo umber' vel cinnamomeo-fuscis, in maturitate 'natal brown'; stipite robusto, 5–25 mm. longo, fere cum radiculis junctione sclerotio; ascis octosporis, 152–200 × 9–12 μ. Ascosporis oblique uniseriatis, unicellulosis, ample ovideis, uno latere leviter planis, hyalinis, biguttulatis, 11–16 × 4–7 μ.

On the ground from sclerotia dehisced from diseased leaves of *Populus tremuloides*. Type: *No. 15624,* Herb. Dept. Plant Path., Cornell University, collected by H. H. Whetzel near McLean, New York, May 23, 1927.

It seems desirable to present also at this time a name for and a more complete technical description of the Colorado fungus collected by Seaver and Shope.

Sclerotinia confundens Whetzel, sp. nov.

Apotheciis pluribus ad multa, superficie tenuium ovalium ad rotundate concavo-convexa nigra sclerotios crescens, cupulatis, 0.5–1.5 mm. diam., siccis pallide luteolis ad alte cremea;[3] stipitibus robustis, 2–3 mm. longis, basilaribus radicularis defectis; ascis octosporis, 45–74 × 4–6.5 μ; ascosporis semiseriatis, fusiformibus ellipsoideis, hyalinis, 7–10 × 2.4–3 μ.

On the ground from free lying sclerotia entangled in leaf debris, under trees of *Populus tremuloides*. Type: *No. 17867,* Herb. Dept. Plant Path., Cornell University. Collected by Seaver and Shope July 29, 1929, Colorado, elevation 9,600 feet.

It will be seen from a comparison of the above descriptions of the apothecia that the two fungi are quite distinct species. The assumption by Seaver and Shope that the sclerotia of *S. confundens* were formed in the leaves of *Populus tremuloides* and were freed after several seasons by decay of the leaf tissues, is highly improbable. All sclerotia of this type, in our experience, produce their apothecia the spring following the season in which they were formed. Moreover, a critical examination of the leaf debris layers in which the sclerotia were entangled disclosed foliar remnants of some other plant along with those of *P. tremuloides* and which may represent the real suscept of *S. confundens.*

[3] According to Seaver and Shope (p. 3) "The whole ascophore is whitish or slightly yellowish" (when fresh, presumably).

The writer has partially completed a manuscript in which will be presented a monographic treatment of *Sclerotinia bifrons, Sclerotinia confundens* and a number of other closely related species. This brief preliminary discussion is published thus in advance of the main paper at the urgent request of a colleague who has ready for publication the results of a rather extensive investigation of the disease caused by *Sclerotinia bifrons.*

DEPARTMENT OF PLANT PATHOLOGY,
CORNELL UNIVERSITY,
ITHACA, NEW YORK

EDITOR'S NOTE

Two species of *Sclerotinia* have been reported on the poplar sclerotium commonly known as *Sclerotium bifrons,* one from the Rocky Mountain variety of *Populus tremuloides* (regarded by some as a distinct species, *Populus aurea* Tides.) and one from the eastern form of *Populus tremuloides.* Unfortunately the same binomial has been applied to both species of fungi. Under the International Rules of Botanical Nomenclature the later homonym is untenable and must be rejected:

> Section 12. Art. 61. A name of a taxonomic group is illegitimate and must be rejected if it is a *later homonym,* that is if it duplicates a name previously and validly published for a group of the same rank based on a different type. Even if the earlier homonym is illegitimate, or is generally treated as a synonym on taxonomic grounds, the later homonym must be rejected.

Therefore, in recognition of the years of work which Professor Whetzel has spent on *Sclerotinia* in general, and the eastern species on poplar in particular, I propose that the name **Sclerotinia Whetzelii** (Syn. *Sclerotinia bifrons* Whetzel 1940. Not *Sclerotinia bifrons* Seaver & Shope 1930.) be adopted to replace the later homonym in order to avoid confusing the eastern and the Rocky Mountain species of *Sclerotinia* on poplar. A detailed account of our western species will appear at some later time.—FRED J. SEAVER.